SURGERY OF THE AMBULATORY PATIENT

CONTRIBUTORS

HARRY M. BURROS, M.D., F.A.C.S.

Associate in Urology, Graduate School of Medicine of the University of Pennsylvania, Urologist to the Graduate Hospital of the University of Pennsylvania; Chief of Urologic Outpatient Department of the Graduate Hospital of the University of Pennsylvania

EDWIN J. PULASKI, Lieutenant Colonel, MC, U.S.A., M.D., D.M.SC. (SURG.), F.A C.S.

Assistant Chief, Department of Surgery. Chief, General Surgical Service, Tripler Army Hospital, San Francisco, California

HRANT H. STONE, M.D.

Associate Professor of Anesthesia, Woman's Medical College of Pennsylvania, Associate Professor of Anesthesia, Graduate School of Medicine of the University of Pennsylvania, Director, Department of Anesthesia, Graduate Hospital of the University of Pennsylvania

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L. KRAEER FERGUSON, M.D., F.A.C.S.

Professor of Surgery, Graduate School of the University of Pennsylvania; Professor of Surgery, Woman's Medical College of Pennsylvania; Surgeon, Graduate Hospital of the University of Pennsylvania, Woman's Medical College Hospital, Philadelphia General Hospital and Doctors Hospital

With a Section on Fractures by

LOUIS KAPLAN, M.D., F.A.C.S.

Senior Attending Surgeon, Albert Einstein Medical Center, Southern Division; [illegible] College; Formerly [illegible] Charge of the Fracture Division of the Surgical Outpatient Department, Hospital of the University of Pennsylvania

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A SYMPATHETIC TEACHER, A WISE COUNSELLOR,
AN EXACTING SURGEON AND A STANCH FRIEND

Preface to the Third Edition

The third edition of *Surgery of the Ambulatory Patient* has been long delayed. The reprintings of the second edition continued to supply the demand, although it was recognized that some portions of the text, notably the section on antibiotics and the treatment of infections, were very much outdated. Revisions could hardly be kept up to date because of the rapidly changing picture in this field.

In this revision, the original purpose of the author has been maintained: namely, to provide a text for the guidance and the consultation of physicians called upon to treat surgical lesions in ambulatory patients. Thus, it is a text written especially for doctors taking care of patients in industrial, military or hospital dispensaries, for the instruction of students in outpatient surgery, and for the use of general practitioners in the diagnosis and the treatment of patients who go to an office.

The revision has been complete, the text has been reset entirely, and the subject matter has been brought up to date. The chapter on anesthesia has been rewritten completely by Dr. Hrant H. Stone, director of the Department of Anesthesiology at the Graduate Hospital. This very important subject has been discussed with particular emphasis upon drugs, methods and procedures that can be used for the office or the home treatment of patients. Safety factors and precautions are stated clearly. The chapters dealing with antibiotics and the treatment of infection are the work of Lieutenant Colonel Edwin J. Pulaski. They provide an authoritative and up-to-the-minute evaluation of the antibiotics and suggestions for their dosage and administration. In addition, there are sections dealing with human bites, dog bites, rabies, snake bites, et cetera, on which subjects there is little information in most texts.

The chapter on genito-urology, written previously by Dr. Boland Hughes, has been rewritten completely by Dr. Harry M. Burros, assistant urologist at the Graduate Hospital. He has included the latest accepted therapies of venereal disease and much new material on urology in the office patient.

New material has been added throughout the entire book. This includes the use of the adrenal hormone preparations in bursitis, ganglion, trigger finger, pruritus ani, et cetera. All new material gleaned from the literature was evaluated by personal experience before it was included in the text. Many new illustrations have been added. In order not to make the book cumbersome, much has been deleted from the former edition, especially some of the lists of references.

Once again this book is offered in the hope that it will continue to be of use to those doctors who treat surgical lesions in patients not confined to hospitals.

L. K. F.

Preface to the First Edition

An experience of some years in treating the surgical lesions which occur in ambulatory patients has indicated the need for a text devoted to this much-neglected branch of surgery. The larger books on surgical practice are usually written by men who are too far away from this type of work to appreciate its problems.

Surgery of the ambulatory patient is the surgery performed more often by the younger men and general practitioners, and it is the hope of the author that this volume may prove an aid to them in their every-day practice. The lesions discussed are those which are met regularly in an office or out-patient clinic, and an effort has been made to describe the best methods of treating them as proved by personal experience. No subject is included in this volume which cannot be cared for in an ambulatory patient, except for a few topics which are mentioned for purposes of differentiating them from the lesions which fall into the sphere of ambulatory surgery. In almost all instances, the author has carried out the recommended therapy and has tried to point out the mistakes of treatment as well as the successes.

The book is divided into three parts. The first is a more or less general discussion of typical lesions, with a description of their cause, course, and care. The second part of the book is on regional surgery. Here are detailed the common surgical lesions of the specific parts and the methods of treatment. The third section deals with fractures and dislocations and their treatment in ambulatory patients.

Many associates and colleagues have aided in the preparation of the material for this book and to them the author expresses his sincere thanks. Dr. Lawrence Curtis has made extensive contributions and suggestions in the chapter on the mouth, Dr. Edward H. Campbell in the sections on the ear and nose, Dr. Donald M. Pillsbury on dermatologic lesions, and Dr. Ivan B. Taylor in the chapter on anesthesia. The chapter on genito-urinary diseases is entirely the work of Doctor Boland Hughes. My associate, Dr. Louis Kaplan, has prepared and written the entire section on fractures and dislocations, as well as the sections on the knee and shoulder. Drs. David P. Anderson and Robert Welty aided greatly in gathering and assembling some of the material. The roentgenograms are in almost every instance from the X-ray Department of the University Hospital and are reproduced through the kindness of Dr. Eugene P. Pendergrass.

Thanks are also due to Miss Edna Hill and Miss Jean McConnell, who made most of the drawings, to Miss Irene Chambers, the head nurse of the Surgical Out-Patient Department at the University Hospital, and to Mrs. Eunice Stevens, who did most of the final stenography.

Contents

Part One

Surgical Principles and Lesions

The author could never have assembled and arranged the material for this book without the unstinting help and suggestions of his secretary, Miss Jean K. Gardiner, and his nurse, Mrs. Bertha Williams. They should be considered almost as co-authors.

Finally the author wishes to acknowledge the encouragement and co-operation of the publishers, the J. B. Lippincott Company.

L. K. F.

Part Two

Regional Surgery

Part Three

The Musculoskeletal System

Part Three

The Musculoskeletal System

PART ONE

SURGICAL PRINCIPLES AND LESIONS

· 1 ·

A Survey of the Field of Ambulatory Surgery

The surgery of ambulatory patients is a subject much neglected in present-day medicine. Surgeons who have large hospital practices often, as a matter of convenience, admit to the hospital patients requiring minor surgical procedures. Here the patients with minor lesions tend to be lost in the more absorbing interest of gallbladder disease, carcinoma of the bowel and other more impressive and dramatic fields of major surgery. Furthermore, the surgeon who is busy with major operations frequently has neither the time nor the inclination to familiarize himself with alternate therapeutic measures which may be applied successfully to ambulatory patients.

The general practitioners and the younger surgeons who see many of the surgical conditions for which ambulatory care should be given are frequently ill prepared to deal with them because of a lack of experience, equipment or assistance. This book has been written particularly to aid this group. No procedure is described which has not actually been carried out in ambulatory patients and which cannot easily and safely be performed when adequate equipment and assistance are available.

SOME GENERAL CONSIDERATIONS

It is probable that more poor surgery is performed on minor lesions of the hand than, for instance, on major brain lesions. The highly trained specialist working almost exclusively in one region becomes expert in his field. In contrast with this localization and intensive specialization, the lesions falling within the field of ambulatory surgery tend to be varied and to be distributed over all parts of the body. Ambulatory surgery, therefore, never can be restricted regionally, nor can it be considered the exclusive field of any specialist. On the contrary, it is an integral part of the work of the general practitioner and of all surgeons. Because of this, the minor lesions treated in ambulatory patients present one of the greatest fields for improvement in surgical procedures and technics.

In general, surgery of the ambulatory patient is concerned with smaller lesions which show clearly the process of injury or disease by simple methods of examination. In contrast, most major lesions must be studied by various clinical examinations, charts, lab-

kemia, even though the lesions are insignificant, are performed best in the hospital because of the danger of postoperative bleeding. In diabetics, even minor operations should be performed in the hospital because of the danger of metabolic complications. Ambulatory surgery should be safe surgery.

oratory reports and a detailed appraisal of symptoms in order to arrive at a diagnosis.

Ambulatory surgery has no mortality, requires few assistants, and usually can be performed in the office or the outpatient department.

ADVANTAGES AND DISADVANTAGES

Methods of treatment which permit the patient to be ambulatory have many advantages. Usually, the patient is able to pursue his regular occupation with little or no disability. This, combined with the fact that he can stay in his own home, means a considerable saving of money and much less inconvenience. Also, the worry and the dread of a hospital stay are avoided.

From the point of view of the surgeon, there are also many advantages. In the first place, the patients do well. Fewer complications develop after operations on ambulatory patients than after the same operations performed on hospitalized patients. For instance, in a large experience with anal operations in ambulatory patients, retention of urine never has been encountered as a complication, although this is well known as a frequent and troublesome complaint in hospital patients In the second place, the end results are satisfactory, comparing favorably with those obtained in similar lesions treated in hospital patients.

Ambulatory treatment is advantageous to the hospital because it reserves the beds for patients actually needing bed and nursing care.

Surgery in the ambulatory patient is not always advisable even though possible. The patient should not be permitted to go home after an operation without a friend or a relative to accompany him. Sometimes home care is required following operations In the case of the patient who should be confined to his room for a day or two but would have to go out for his meals, it is perhaps wiser to take advantage of the facilities of a hospital Ambulatory surgery usually requires also that a physician be available for call. Emergency care is necessary only infrequently, but safety demands that it be available.

SELECTION OF PATIENTS AND PRECAUTIONS

In the selection of patients for ambulatory care there should be no question as to the advisability or the possibility of completing the therapy decided upon. Major surgery requiring a close watch over the postoperative course should not be attempted. When the diagnosis is in doubt or the extent of the lesion is not definitely known, the operation should not be performed on an ambulatory patient. The author had the experience of removing a sarcoma of the thigh which had been diagnosed preoperatively as a lipoma; this taught him a lesson in this regard

Constant care must be exercised in doubtful cases. Smallness is not at all synonymous with unimportance, and the surgeon must be constantly on his guard. Moreover, the general practitioner who will usually recognize acute appendicitis and will send his patient to the hospital for immediate surgical attention will frequently fail to recognize or to evaluate the danger of a small malignant growth or a boil on the upper lip.

Operations upon patients with blood dyscrasias, such as hemophilia or leu-

low are the result of much experience in this type of surgery. In procuring instruments, materials and so forth, it is economy to purchase the best.

OPERATING ROOM

The operating room need not be large (Fig. 1). It should have sufficient light and ventilation, and should be easy to keep clean. Painted or tiled walls are easily washed and are therefore preferable. A floor of tile or linoleum is suitable, and a wide door is desirable. A lavatory with hot and cold running water which can be mixed in a single faucet should be easily accessible; a spigot control at the knee or the foot is very useful. The room should be fitted with several electric sockets for the attachment of lights, small sterilizers and other appliances operated electrically.

FURNITURE

Cabinet. Either in the room used for operating or easily accessible to it there should be an instrument cabinet (Figs. 2 and 3). The style with glass doors and shelves above and a number of drawers or a cupboard below is the most convenient.

Tables. One or two small tables with agate, metal or glass tops, and mounted on wheels, should be available. The operating table may be any simple table, but it should have a padded cover and should be adjustable so that the foot of it drops down. Stirrup attachments are necessary. The Hanes type of proctoscopic table (Figs. 4-6) has been found to be adequate for all purposes of minor surgery, and it may also be used for anal and rectal examinations.

Stools. Two types of stools have been found to be convenient: one, of wood or, better, of painted steel, should be adjustable for height (Fig. 8); the other, a small stool about 15 in. high, is the type commonly sold for use in bathrooms (Fig. 7). A sturdy footstool is extremely useful (Fig. 9).



Fig. 2. A useful type of instrument cabinet. The cabinet is lighted automatically when the door is opened, so that light is thrown upon the entire layout on the glass shelves. The lower portion of the cabinet is a cupboard. The drawers are handy places for storing bandages, adhesive and other supplies.

2.

Equipment for Surgery of the Ambulatory Patient

An extensive outlay of equipment is not necessary for the treatment of surgical lesions in ambulatory patients. Naturally, the requirements vary somewhat according to the lesions to be treated. The suggestions which fol-

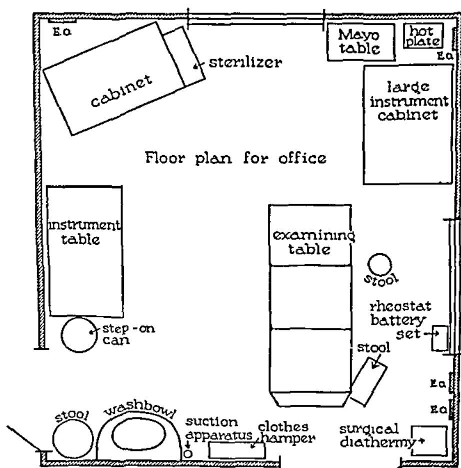


FIG. 1. Floor plan of a room equipped for surgery on ambulatory patients. The letters "E.O." signify the location of electric outlets

FIGS. 4-6. Hanes proctoscopic table.

FIG. 4 (*Right, top*). Horizontal position, which is used for general examinations and most minor operations.

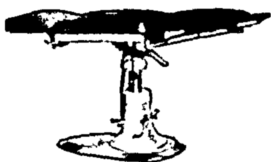


FIG. 5 (*Center, left*). Foot of table lowered in preparation for proctoscopic examination. The patient faces the table with his feet upon the footrest. He then bends forward over the table, places his elbows in the angle formed by the headrest and the body of the table, and rests his forearms and hands on the upright portion.

FIG. 6 (*Center, right*). Table inverted in preparation for anal and rectal examination.

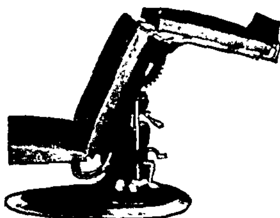


FIG. 7. Enamel-finished bathroom stool. It is small, light in weight and extremely useful in office surgery.



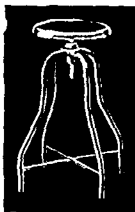


FIG. 8. Adjustable stool.

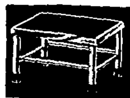


FIG. 9. Footstool.

Instrument Stand. The Mayo instrument stand (Fig. 11) is very useful, since it can be adjusted for height and placed over the operating table. However, if desired, instruments may be placed on a tray on one of the small tables.

Light. Adequate light on the operating field is essential, and, because of the variety of lesions to be treated, the light must be easily adjustable. The gooseneck light (Fig. 10) on a pedestal meets these requirements very well. There are several others; they have some advantages but they are more expensive.

Sterilizer. An electric sterilizer (Fig. 3) is necessary; it should have a tray at least 16 to 18 in. in length for sterilizing such long instruments as the proctoscope and so forth.

Autoclave. Steam autoclaves electrically heated are available in various sizes for office use. They are not difficult to operate, and they have the advantage of permitting easy sterilization of dressings, solutions, instruments and other materials (Fig. 12).

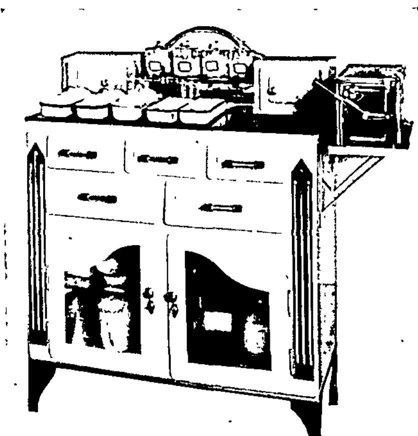


FIG. 3. Instrument and supply table with electric sterilizer. This type of table with drawer and cupboard space is sufficiently large for storing all supplies in frequent use. The white enamel trays with lids are used for sterile syringes and needles; the others are used for dressings.

1 Scissors, small straight
6 Jones towel clips
3 Scalpels for detachable blades
Bard-Parker blades, Nos. 10, 11, 15
2 Needle holders, 6-in. Mayo type
Needles—Lane's 1/2 circle, Nos. 2, 3, 4, 6
Keith's 1 3/4-in. abdominal, No. 9
Ferguson's round point 1/2 circle, No. 12
Kelly's intestinal, No. 1
6 2-in. pieces of large rubber tubing used as spools for ligatures and sutures

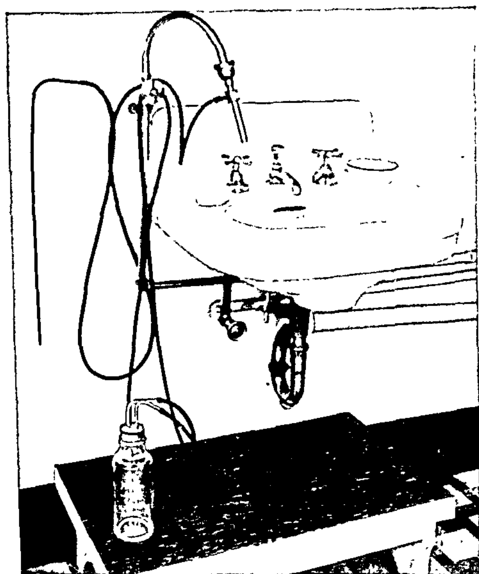


Fig. 13. Water-suction apparatus attached to the wash basin. Suction is connected by a rubber tubing to a trap bottle, and from it leads another tubing with a long metal suction tip bent at right angles. This is used for the removal of fluid and secretion during proctoscopic examinations. A smaller sterile suction tip may be attached for the removal of pus and other fluids in sterile operations.

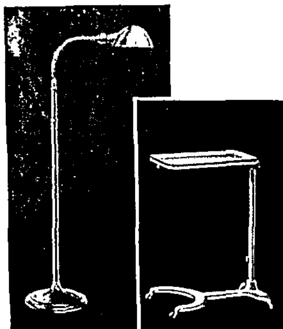


FIG. 10 (*Left*). Gooseneck lamp.

FIG. 11 (*Right*). Mayo instrument stand.

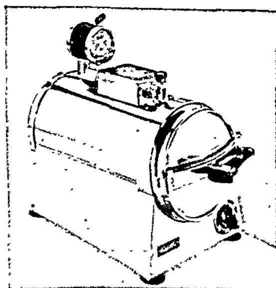


FIG. 12. Electric autoclave for office use for sterilizing instruments, syringes and needles, solutions and dressings. (Wilmot Castle Company, Rochester, New York)

ACCESSORIES

A distinctly useful accessory is some form of suction. This can be installed cheaply as a water suction, or it can be obtained by installing an electric suction pump, several of which are on the market (Fig. 13).

Leg rests are particularly useful in treating lesions of the lower extremity. They should be of white enamel or of Allegheny metal for easy cleansing (Fig. 14).

Baskets for waste and soiled dressings should be of metal. The open type or those types with lids may be used as preferred. The latter are frequently hard to use and are often out of order; the open type is simple and is serviceable if kept clean. Metal baskets, painted and lined with wrapping paper, are very serviceable.

INSTRUMENTS

The instruments required for operation are relatively few. As a rule, the lesions to be treated are small; therefore, the instruments are smaller than those used for major surgery.

The list of instruments suggested for adequate equipment is as follows:

6 Hemostats, straight Halstead
6 Hemostats, 6-in curved Halstead
6 Hemostats, mosquito straight
6 Hemostats, mosquito curved
6 Allis forceps
6 Forceps, 4-in dressing
2 Forceps, 4-in. iris
4 Rake retractors, sharp points, 3 teeth
3 Probes
2 Groove directors
1 Curet
2 Scissors, 5-in. straight
1 Bandage scissors
2 Scissors, 5-in. curved
1 Scissors, small curved

This can be used with one hand and does not tend to get out of order as quickly as does the so-called plunger type. A disadvantage, however, is that it cannot be used easily when inverted; in such a situation the plunger syringe is preferable.

USUAL TRAY SETUP

The setup of the usual tray (Fig. 16) for minor surgical lesions contains the following:

2 or 3 Hemostats, mosquito, curved
2 or 3 Hemostats, mosquito, straight
3 Hemostats, straight Halstead
2 Hemostats, curved Halstead
2 Allis forceps
2 Jones towel clips
2 Rake retractors, small, 3 teeth
1 Forceps, 4 in. dressing
1 Forceps, 4-in. iris
1 Scissors, 5 in. straight
1 Scissors, 5 in. curved
1 Scalpel with Bard-Parker blade No. 10
1 Luer-Lok anesthesia syringe, 5 or 10 cc.
2 Anesthesia needles, 1 small (25 gauge, ¾ in.) and 1 large (22 gauge, 2½ in.)
1 Solution cup or medicine glass for anesthesia
1 Keith's abdominal needle, No. 9
1 Kelly's intestinal needle, No. 4
1 Lane's ½-circle needle, No. 2 or 3
Small sponges
Large dressings
1 Needle holder
Suture material

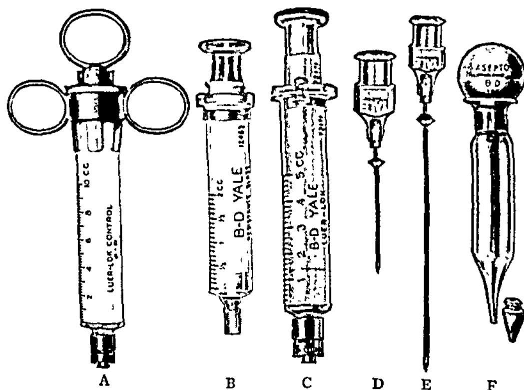


Fig. 15. Syringes and needles (A) Luer-Lok thumb- and finger-ring syringe for local anesthesia. (B) All-glass Luer 2-cc. syringe. (C) Luer-Lok 5-cc. syringe for injection of veins and other uses. (D and E) Needles with safety knob for local anesthesia. (F) Asepto syringe, 1 oz., useful for irrigation.

SUTURES AND LIGATURES

Catgut, plain, 0, 00 and 000
20-day chromic, 1
Horsehair, 20-in. length
Dermal, 0, 00, 000 and 0000
Alloy steel wire, 0.006 fine
Alloy steel wire, 0.010 heavy
Kal-Dermic, 0000 and 000
Champion silk, 0 fine
Champion silk, 2 medium
Deknatel, 0.006 very fine
Deknatel, 0.008 fine
Deknatel, 0.010 medium
Deknatel, 0.012 heavy
Surgical nylon, 0.006
Surgical nylon, 0.009
Surgical nylon, 0.012
Cotton thread, 50-100 fine
Cotton thread, 36-50 black

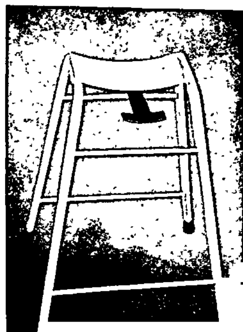


FIG. 14. Leg rest. This enamel leg rest is useful in treating lesions of the lower extremity. The black T-shaped metal extension is a heel rest which facilitates the application of dressings to foot and ankle.

SYRINGES AND NEEDLES

Hypodermic Syringes. A considerable variety of syringes is necessary. For the administration of local anesthesia, the syringes with thumb and finger rings and needle lock are the most suitable. Those made entirely of glass, except for the finger rings and the needle lock, are preferred (Fig. 15A). Two such syringes at least should be on hand. For the administration of hypodermic injections into varicose veins and for numerous other procedures, the ordinary all-glass syringes with the Luer tip are used (Fig. 15B). These vary in size from the 1-cc. vaccine syringe, in minim as well as in metric graduations, up to the more commonly used 2-, 5- and 10-cc. syringes. Occasionally, a 20-cc. syringe is found to be useful. The needle with the Luer hub (Fig. 15D and E) is used with these syringes, and the sizes most commonly employed are as follows:

For the administration of vaccines and other forms of hypodermic medication, for the injection of varicose veins and for some types of local anesthesia: Nos. 22, 23 and 25 gauge, ¾ in.; No. 26 gauge, ½ in.

For the injection of oil-soluble anesthetics: No. 19 or 20 gauge, 2 in.

For the aspiration of joint cavities, hematomas and so forth: No. 13, 14 or 15 gauge, 2 in.

For the injection treatment of hemorrhoids: Goldbacher hemorrhoidal needle.

For deep infiltration, such as field block and nerve block anesthesia: No. 22 gauge, 2½ in.

Irrigating Syringes. One or two syringes for irrigating infected wounds or cavities should be at hand. The most useful type for this purpose is the glass syringe with a rubber bulb suction (1- or 2-oz. Asepto) (Fig. 15F).

for operations, the instruments should be protected from the tray on which they are placed by some sterilizable waterproof material. These tray covers may be of heavy canvas or of mackintosh rubber. The tray drape is made conveniently from heavy unbleached muslin, 36 x 36 in. This size is large enough to fold the edges over the tray to protect it from contamination before it is used. Drapes for the field of operation are made of heavy unbleached muslin, about 18 x 18 in containing an aperture through which the operative field is exposed. Several such drapes with openings made at various locations, some in the center and some placed eccentrically, will permit the surgeon to choose the drape which best fits the operation at hand. The opening should be about 2 to 4 in. in diameter, and a binding of tape or a facing of itself will prolong the period of usefulness. Instead of the drapes as described, towels of linen or crash may be draped about the wound and held in place by towel clips. In addition, towels which can be sterilized should be provided for use after scrubbing the hands.

Surgeon's Outfit. As a rule, in operating upon the minor lesions of ambulatory patients, it is not necessary for the surgeon to wear an operating suit. Often, however, and especially during hot weather, a short smock is desirable. During the scrubup, a rubber apron will protect the surgeon's clothes, and it may be worn as a protection during certain types of operations. Good surgical practice recommends that during an operation the

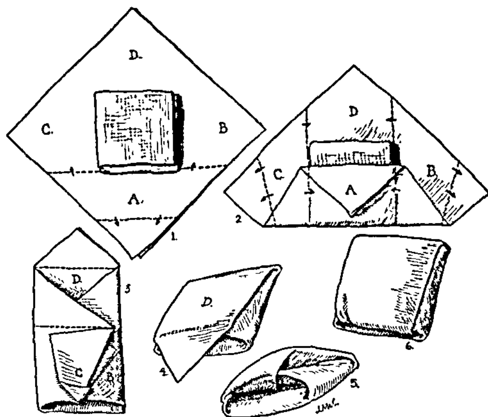


Fig. 17. Method of wrapping gauze compresses in paper napkins for sterilization.

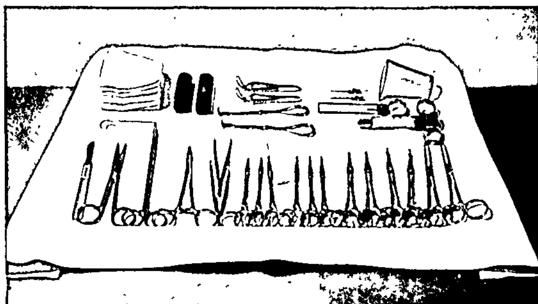


FIG. 16. Usual setup of tray for operations on minor surgical lesions.

ADDITIONAL INSTRUMENTS AND ACCESSORIES

The following instruments and accessories may be used infrequently, but it is advisable to have them at hand in case of need:

1 Bone-cutting forceps, 6 in.
1 Rongeur, 6 in.
Electrocautery
Surgical diathermy
Band retractors
Sphygmomanometer
Cast cutter
Alcohol lamp
Thermometer
1 Enamel or glass graduate, 1,000 cc.
Razor
Rubber tubing, sizes $\frac{1}{8}$, $\frac{3}{16}$, $\frac{1}{4}$ and $\frac{5}{16}$ in.
Rubber dam
Sponge rubber
Plain gauze (ribbon) packing, $\frac{1}{2}$ and 1 in.
Folded gauze packing, $\frac{1}{2}$ and 1 in.
Iodoform gauze packing, $\frac{1}{2}$ and 1 in.
Petrolatum gauze
Paraffin mesh

The packing may be bought already prepared, or it may be made and prepared for use; directions for its preparation will be found in standard textbooks on surgical nursing.

UTENSILS

The following list of utensils is suggested as standard equipment:

Small solution cups, agate or Allegheny metal
Emesis basins, large and small
Instrument trays, 3 x 8 or 6 x 8 in.
Hand brushes
Covered glass jars, 4 x 4 in. for cotton sponges and 6 x 6 in. for dressings, bandages and so forth
Rack for roll adhesive
Agate basins

SUPPLIES

Sheets, Pillows and Pillowcases. Sheets which are large enough to cover the patient completely are preferable. At least one pillow should be covered with rubber or oiled silk under the muslin or percale case.

Covers and Drapes. In the setup

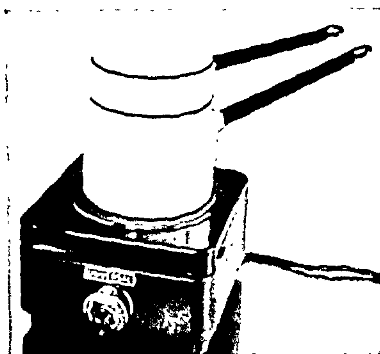


FIG. 18. Double boiler and electric stove for preparing Unna's paste.

lesions to be treated. The following list is not complete, but it does include those most commonly employed:

Physiologic saline
Saturated boric acid (for irrigations)
Procaine 0.5, 1 and 2 per cent (for local anesthesia)
Sodium morrhuate 5 per cent, 50 per cent glucose, 30 per cent sodium chloride (for injection of varicose veins)
"Pure" phenol
Silver nitrate sticks and 10 per cent solution
Balsam of Peru
Whitehead's varnish: Ethereal tr. benzoin compound, 4 parts; iodoform, 1 part
Benzene
Hydrogen peroxide
Alcohol 70 per cent
Epinephrine hydrochloride
Formalin
Green soap
Tr. benzoin
Aromatic spirits of ammonia
Carnoy's solution
  Absolute alcohol ....6.0 cc.
  Chloroform ....3.0 cc.
  Glacial acetic acid ....1.0 cc.
  Ferric chloride ....1.0 Gm.
Carabba's solution
  Phenol ....45 cc.
  Borax ....16 Gm.
  Salicylic acid ....16 Gm.
  Glycerin ....120 cc.
  Spirits of camphor q.s. ad ..240 cc.
Ointments
  Zinc oxide
  Mercurial, 50 per cent
  Petrolatum

UNNA'S PASTE FOR GELATIN BOOTS

Unna's gelatin mixture is a supporting dressing which is used frequently, especially on the lower leg. It is prepared in a double boiler (Fig. 18) as follows:

Gelatin ....200 Gm.
Zinc oxide pulv..........100 Gm.
Glycerin ....400 cc.
Hot water ....375 cc.

surgeon wear a cap and a mask, a sterile gown and gloves. Gowns are wrapped and sterilized separately. Gloves should be tested, powdered and sterilized in special glove wrappers.

Compresses and Dressings. The gauze compresses and dressings found to be most convenient are of two sizes, 3 x 3 in. and 4 x 8 in. They may be procured already cut and folded from the manufacturer. They are sterilized in groups of three or four wrapped in paper napkins (Fig. 17); the advantage of this technic is that there is no danger of contamination, as is the case when dressings are sterilized in bulk in jars.

Bandages. The most convenient bandages are those which are wrapped individually in paper. The gauze should be of the wide mesh, 28 x 24 to the inch. The smaller-mesh gauze contains so much sizing that it is applied with much more difficulty. The bandage sizes most frequently used are 1, 2, 3 and, less often, 6 in. In addition to gauze bandages, muslin bandages frequently are necessary and are used most often in 3-, 4-, 5- and, sometimes, 6-in widths Bandages of outing flannel are sometimes used in 3-, 4-, 5- and 6-in widths as a relatively inefficient but inexpensive substitute for the woven elastic bandages now available. A supply of the woven elastic bandages should be available in 2- and 3-in. widths.

Cotton. This may be used in two grades. The first-grade absorbent cotton is used for cotton balls, swabs and so forth; the less-absorbent cheaper cotton is used for padding splints. Cotton batting cut in strips of 4 and 6 in. is often used under casts and for padding splints. Felt should be available for some forms of fracture dressings.

Swab Sticks. Swab sticks 6 in. long have numerous uses, and longer ones of 15 in. are employed for proctoscopic examinations. Tongue depressors are needed for mouth and throat examinations, and are often useful as splints.

Safety Pins. These are needed for use in drainage tubes and for holding slings and muslin bandages.

Slings. Triangular slings are made of unbleached muslin. The adult size is made by cutting diagonally across a 1-yd. square of unbleached muslin. The child's sling is made by dividing the adult size in two.

Adhesive. Zinc oxide adhesive plaster is a necessity for the application of most surgical dressings; in addition it is used for adhesive strappings in many traumatic injuries. It is more conveniently used in cut rolls, and the best type is that made with a cloth back, because it adheres more evenly to the skin and is more easily applied. The adhesive made with a back which is impervious to water is much more difficult to apply, and, except for the fact that it sheds water, has no advantages and many disadvantages. The sizes of adhesive most used are ½, 1 and 2 in. The larger sizes, if bought in any quantity, usually dry up and become useless before they are used, or one must go to the trouble of tearing the roll to get narrower widths. Elastic adhesive bandage is a relatively recent and extremely useful type of adhesive. It is used most often in 2- and 3-in. widths. Some patients show a local sensitivity to adhesive. In such cases, Cellophane (Scotch) tape may be used. This is available in ½-in. widths on rolls.

SOLUTIONS AND OINTMENTS

The solutions necessary for the treatment of ambulatory surgical patients vary according to the type o

3

Anesthesia

HRANT H. STONE*

INTRODUCTION

Anesthesia serves two purposes when used for surgery: first, it relieves pain, and, second, it produces muscular relaxation. These desired effects may be accomplished by administering a general anesthetic, which produces loss of consciousness and increasing depression of the central nervous system, or by using local anesthetics, which interfere with nerve conduction.

Minor surgical procedures, such as those usually performed on the ambulatory patient, require little, if any, muscular relaxation and may be performed easily with an adequate degree of pain relief. However, major surgical procedures frequently require profound muscular relaxation as well as pain relief. Muscular relaxation is obtained by using deeper planes of general anesthesia or more extensive methods of local anesthesia. Procedures requiring this degree of anesthesia are not performed electively on the ambulatory patient.

Local anesthesia is the method of choice for the ambulatory patient and should be employed whenever or wherever feasible. The success of local anesthesia depends upon gaining the confidence of the patient. This may be accomplished by careful explanation as to what is being done, by patience and skill, and by warning the patient before an unanesthetized area is to be injected. The surgeon must be gentle and adept at using local anesthesia. His knowledge of anatomy must enable him to produce complete anesthesia by the skillful placement of the needles and the use of small amounts of local anesthetic drugs. It is of the utmost importance that the surgeon impress the patient with his adeptness and ability in the use of local anesthesia. Though it is often time consuming, repeated reassurance of the patient that all is well does much to maintain his confidence and co-operation. Even young children may be given local anesthesia if the surgeon will take the time to gain the patient's confidence. Local anesthesia is doomed to failure if the patient is deceived into believing that the surgery will be painless and then is subjected to discomfort.

Local anesthesia possesses many advantages over general anesthesia for the ambulatory patient. The equipment necessary for local anesthesia is simple and readily available. The anesthesia is administered by the surgeon and may be augmented or extended according to the needs of the surgery.

*Associate Professor of Anesthesiology, University of Pennsylvania, Graduate School of Medicine; Woman's Medical College; Director, Department of Anesthesiology, Graduate Hospital, Philadelphia, Pa

Dissolve the gelatin in the hot water. Mix the glycerin and the zinc oxide powder until smooth, then add to the dissolved gelatin. Cook in the double boiler for one half hour. This makes enough paste for 4 or 5 boots.

SPECIAL SUPPLIES

Numerous other special supplies are required for the care and the treatment of various types of lesions. These are listed under the conditions for which they are used: for instance, supplies necessary for the treatment of ambulatory fractures are listed in the chapter on fractures; those needed for treatment of anorectal diseases are mentioned in the first part of that chapter.

2. Rapid rate of induction
3. Rapid rate of recovery
4. Nonexplosive or noninflammable
5. Simplicity of administration
6. Lack of toxicity

Liquid inhalation anesthesia agents may be administered by the open drop technic or by the use of an anesthesia machine. The gaseous agents must be administered by an anesthesia machine. The open drop technic possesses definite advantages in that it is simple, inexpensive and easy to use. From 7 to 10 layers of gauze applied to the mask permit a free gaseous exchange. Excessive thicknesses of gauze may cause CO_2 retention and even hypoxia. The open-drop technic in the hands of the inexperienced anesthetist provides a wider margin of safety than would be present if one of the conventional anesthesia machines were used. Greater danger from anoxia, overdosage of agent and CO_2 retention is encountered in the use of such machines, which necessitate close and constant observation of the patient.

The general anesthetic agents which are of the greatest value for use in the ambulatory patient are in the order of their importance:

1. Thiopental sodium (Pentothal)
2. Trichlorethylene (Trilene)
3. Nitrous oxide and oxygen
4. Cyclopropane
5. Vinyl ether (Vinethene) and ethyl chloride for children
6. Ethyl ether. Ethylene and chloroform are rarely used

INTRAVENOUS ANESTHESIA

Thiopental Sodium (Pentothal)

Since the introduction of intravenous thiopental in 1934, this drug has shown a great increase in popularity and has been accepted as a safe method of producing general anesthesia. This acceptance, unfortunately, has emerged from the (painful) realization of the limitations and the dangers associated with its use. At present, if these limitations are recognized, and if the possible complications following the administration of thiopental are understood, then it may be used with safety in the ambulatory patient. Thiopental is a barbiturate which acts very swiftly, and, when administered intravenously, produces rapid and pleasant anesthesia. Its rapid effects are attributed to the presence of the sulfur atom in the molecule (thiobarbiturate). It is the sulfur analogue of pentabarbital (Nembutal). It is a yellow amorphous powder readily soluble in water. The resulting solution is definitely alkaline (pH 10.4 to 10.6), which accounts for the high incidence of phlebitis associated with the injection of the drug and also for the severity of the local irritation with its inadvertent extravascular injection. The drug is supplied in ampules of 0.5, 1.0 and 5.0 Gm. By dissolving the drug in sterile distilled water, a 2.5 per cent solution may be produced and has proven to be the optimum concentration to employ. However, more concentrated solutions are used (5 per cent), but this usually increases the total dose of drug administered and prolongs recovery.

Like other barbiturates, thiopental is not a true anesthetic drug. It possesses sedative and hypnotic properties and only serves as an anesthetic when larger doses are administered. The drug produces excellent amnesia, so that even though the patient reacts to the pain of surgery, little is recalled following recovery. This fact makes thiopental a most useful drug for the ambulatory patient. A minor operation, such as the incision and the

Consciousness is not lost, and the various protective body reflexes remain active. Recovery from the effects of the anesthesia is rapid, permitting early and safe ambulation. The agents used for local anesthesia are not explosive or inflammable.

General anesthesia should be reserved for the very young patient and others who are un-co-operative or refuse local anesthesia. While recent trends favor more extensive use of general anesthesia for the ambulatory patient, the limitations and the dangers of the method must be fully understood. General anesthesia should be administered by a qualified nurse or physician who is familiar with the various general anesthetic agents, their use and the complications which may arise during or following their use. The gaseous anesthetic agents require elaborate and costly equipment for their administration. A method of administering oxygen under pressure must be available at all times when general anesthesia is employed. Loss of consciousness depresses body reflexes and greatly prolongs recovery. Adequate facilities, including personnel, must be present in the office to permit full recovery. General anesthesia presents many more hazards to the ambulatory patient than does local anesthesia. A nurse must be in attendance whenever general anesthesia is administered to the female patient to obviate medicolegal complications.

All patients to whom general anesthesia is to be given should be questioned regarding their state of health, with special emphasis upon cardiac and cerebral symptoms. Recent upper respiratory infections are noted. Any history of previous anesthesia, surgery and complications should be ascertained. A brief physical examination should be performed, blood pressure, pulse and respiration being noted. A more extensive examination is indicated when dealing with patients of questionable physical status. The use of a belladonna drug prior to general anesthesia reduces secretions and adds safety to the method. Its routine use is recommended. Atropine is preferred to scopolamine because of the absence of confusion and depression, which often accompany the use of scopolamine. The drug may be administered intramuscularly or intravenously. The intravenous route produces immediate effects. It is dangerous to administer general anesthesia to patients who have had food or water less than 6 hours prior to anesthesia. If this situation is encountered, surgery should be postponed until sufficient time has elapsed to ensure that the stomach is empty.

EQUIPMENT NECESSARY FOR GENERAL ANESTHESIA

In addition to the equipment necessary for the actual administration of general anesthesia, other items should be present in the office for the protection of the patient. These include oropharyngeal and nasopharyngeal airways, endotracheal tubes, a laryngoscope, a suction machine and suction catheters, and a method of administering oxygen for resuscitation. In spite of these items of equipment, general anesthesia is only as safe as the experience of the administrator.

GENERAL ANESTHETIC AGENTS

The ideal general anesthetic drug should possess the following properties:

1. Potency (so that at least 20 per cent oxygen may be administered with the drug)

tions and the most common. During thiopental anesthesia, the laryngeal reflex remains active, and, with the slightest stimulation of the larynx, spasm develops. Stimuli most commonly encountered are initiated by foreign substances in the lower pharynx, such as mucus, blood or anesthetic airways. The preoperative use of a belladonna drug, such as atropine sulfate (0.4 mg.), greatly decreases the incidence of this dangerous complication. Atropine may be injected intravenously immediately before the thiopental is administered. Many who use thiopental in the ambulatory patient, especially dentists, object to atropine because of the annoying dryness of the mouth and flushing of the face which it produces. However, it greatly increases the safety of the anesthesia. The avoidance of the early use of airways, the maintenance of light anesthesia and the head-down position (Trendelenburg) when oral or nasal bleeding is encountered are measures which decrease the incidence of laryngospasm.

Thiopental should not be used in the child or the aged patient. It should be avoided in patients with chronic respiratory diseases, anemia, dyspnea from any cause or obesity or in any patient in whom maintenance of airway is difficult.

Recovery from anesthesia occurs within 10 to 15 minutes in the average adult. The patient should not be discharged from the office until all reflexes have completely returned and the upright position can be maintained without ill effect. If the total amount of drug injected exceeds 0.5 Gm., the patient should be detained for at least one half hour.

Thiopental is an excellent drug if used properly and reserved for the correct patients. Its great danger lies in its ease of administration.

INHALATION ANESTHESIA

The use of inhalation anesthesia for the office patient should be limited to those in whom local and intravenous anesthesia is contraindicated. It is best for the child, although, with proper and careful instruction, local anesthesia may be used satisfactorily for the young patient. From time to time one encounters a patient who refuses both local and intravenous anesthesia and requests inhalation anesthesia. Inhalation anesthesia in the surgeon's office poses many more problems, since it entails an experienced administrator and costly special apparatus.

Trichlorethylene (Trilene)

Trichlorethylene is one of the newer general anesthetic agents which promises to be one of the most valuable for the ambulatory patient. Popularized in 1941 by Hewer in England,[21] the use of this drug has spread to this country. It is a colorless liquid with an odor resembling that of chloroform. It is stored in colored glass ampules to prevent decomposition. The drug is marketed as Trilene and is colored blue for identification purposes. It is stable and does not deteriorate seriously with age. It resembles chloroform in many respects, but is less toxic to the heart and other organs. The drug is potent and capable of producing deep anesthesia, but, with depth, the incidence of respiratory depression and cardiac arrhythmia increases. Therefore, it is best to use it as an analgesic agent in light planes of anesthesia, and depth should be avoided. As the vapor is not pungent, it is inhaled easily and produces smooth induction. Recovery is rapid.

drainage of an abscess or the reduction of a fracture, should be performed in a depth of anesthesia which *permits response by the patient.* This response indicates that an excessive dose of drug has not been administered and serves to regulate additional drug injections. When using thiopental in the ambulatory patient the least amount of drug injected which permits completion of the surgery is the safest.

Thiopental is an extremely potent drug *capable of producing total anesthesia.* In produces a rapid and pleasant induction, which accounts for its high patient popularity. Contrary to belief, rate of recovery is slow and depends upon the total amount of drug injected.[34] The apparent rapid recovery following the administration of thiopental is due to its rapid removal from the plasma and to the accumulation of the drug *in the fat depots* of the body, where the concentration may be from 6 to 12 times greater than that in the blood plasma. With time, the drug stored in the fat depots is fed back into the blood stream *and is slowly detoxified (10 to 15 per cent per hour). As a result, the patient* who has received thiopental must be observed closely following initial recovery from narcosis to prevent such complications as could occur with returning depression. The ambulatory patient who has received thiopental *must be permitted to recover completely* before leaving the office.

Thiopental is nonexplosive and not inflammable and may be used with any type of electrical apparatus. It is very easy to administer, but because of this ease it has been misused and has *produced* a high incidence of serious complications. It is best to inject the drug intravenously as a 2½ per cent *solution. Any accessible vein may* be used with a preference for the arm veins. After venipuncture is performed, the syringe containing the drug is secured to the arm, and slow intermittent injections are made. An initial injection of 100 mg. of thiopental is made fairly rapidly as the patient counts aloud. Usually this amount will induce anesthesia without depressing respiration. Additional amounts may be given (25 to 50 mg.) according to the needs of the patient *and repeated as necessary.* It is best to wait and ascertain fully the effect of an injected dose of drug before repeating the injection. With loss of consciousness, airway must be maintained by the anesthetist. Respiratory exchange must be noted constantly, especially following any injection of thiopental. This drug is a direct respiratory depressant. Overdosage produces *death by asphyxia.* Therefore, when administering thiopental, 100 per cent oxygen should be given concomitantly by face mask and breathing bag. If apnea develops due to overdosage, artificial respiration must be instituted at once *with 100 per cent oxygen and maintained until* adequate spontaneous respirations return. The importance of patent airway and adequate respiration cannot be emphasized too strongly in using thiopental.

In order to decrease the total amount of drug injected, all should *be in readiness prior to the induction* of anesthesia. The patient should be in place and gently secured in position on the operating table. The surgeon and the instruments should be in readiness As soon as consciousness is lost, the surgery should begin.

A *number of complications may* arise when thiopental is being used. Laryngospasm is one of the most se-

levels. The administration of such hypoxic mixtures undoubtedly accounts for the severe complications associated with this drug. While nitrous oxide-oxygen has been used extensively in the office, especially by the dentist, the trend today is away from the use of nitrous oxide as the sole anesthetic. Realizing its limited potency, nitrous oxide is now used in combination with other drugs of greater potency, such as ethyl ether, vinyl ether, thiopental and trichlorethylene. Such combinations increase potency without encroaching upon oxygen content and greatly increase the safety of the agent. For instance, when combining nitrous oxide-oxygen with ethyl ether, a concentration of 50 per cent nitrous oxide and 50 per cent oxygen may be used while obtaining adequate depth of anesthesia.

Cyclopropane

Cyclopropane continues to be one of the most important and valuable anesthetic drugs in use today. It is an extremely potent drug, capable of producing total general anesthesia. Induction and recovery from anesthesia when using this agent is rapid and pleasant. It is highly explosive and inflammable and, therefore, must be administered with all safeguards against explosions. In the office, the conventional safeguards against fires and explosions cannot be observed and, therefore, the hazard of using this drug is increased. Being a gas, cyclopropane must be administered by an anesthesia machine using a method of carbon dioxide absorption. Despite its many advantages, cyclopropane in general appears to be too much anesthesia for the requirements of the ambulatory patient. The extreme potency of the agent, the potential respiratory and circulatory complications which may follow its use, serve to discourage its general use in the office.

Vinethene (Divinyl Ether)

Vinethene, which is pure divinyl ether rendered less volatile and more stable by the addition of 3.5 per cent absolute alcohol and 0.01 per cent of a nonvolatile oxidation inhibitor, is an excellent inhalation anesthetic agent, particularly for short procedures.[38-40] It is a clear fluid with a nonirritating odor. It is quite unstable and is easily decomposed by heat, light and air; therefore, a bottle which has been exposed to air for a period longer than 24 hours should be discarded. The drug is very potent and highly volatile. Induction is pleasant and rapid. Within 30 to 50 seconds following the open drop administration of the drug, consciousness is lost. Recovery from anesthesia is likewise rapid, with little nausea or vomiting. Vinyl ether is highly explosive and inflammable, so that the precautions advocated for the prevention of these complications must be observed. The drug can simply be administered by the open drop technic or, if desired, by means of an anesthesia machine. Its potency, its smooth, rapid induction, its simplicity of administration and the rapid recovery obtained from it make it the ideal agent for pediatric anesthesia, especially for the ambulatory patient. It continues to be widely used for this purpose, and because it is much safer than ethyl chloride, is the drug of choice both as an inducing agent and as the sole anesthetic. Circulatory and respiratory complications are rare during and following anesthesia. However, because of the potency of the drug, excessive



Fig. 19. The Duke University inhaler Self-administration of trichlorethylene is safe and reliable with this apparatus.

The drug is nonexplosive and noninflammable and may be used in the presence of various types of electrical apparatus Administration of the drug has been greatly simplified. It is not used in the conventional anesthesia machines because of toxic decomposition products that may result. Various inhalers ("Duke" Fig. 19) have been devised which permit self-administration of the drug.[45] With this type of apparatus, the patient is instructed to apply the mask to the face and breathe normally. Very quickly, inhalation of the vapor produces loss of consciousness and affords excellent analgesia. With depression of consciousness, the mask falls from the face, and the patient quickly recovers. If additional anesthesia is required, *the process is repeated as the patient* awakens. If more sustained anesthesia is sought, the mask is kept on the face by the anesthetist after self-induction by the patient. Tachypnea is one of the reliable signs of overdosage and should be avoided.

Because of the lack of irritative properties of trichlorethylene vapor, overdosage is always a danger. Excessive blood-stream concentrations produce cardiac arrhythmias and respiratory depression. When depth of anesthesia is restricted to lighter planes, almost any minor surgery may be performed safely on the ambulatory patient when this agent is used.

Nitrous Oxide–Oxygen

Except for lack of potency, nitrous oxide most closely approaches the ideal anesthetic drug. It produces a pleasant induction and permits rapid recovery with little nausea and vomiting. It is nonexplosive and noninflammable. Being a gaseous agent, it must be administered by an anesthesia machine, and it requires a qualified anesthetist. For patient safety, at *least 20 per cent* oxygen must be administered with the nitrous oxide. In the unpremedicated ambulatory patient, often 80 per cent nitrous oxide is not sufficiently potent to produce anesthesia. Increasing the concentration of nitrous oxide to 85 per cent or more adds potency but decreases the concentration of oxygen to anoxic

levels. The administration of such hypoxic mixtures undoubtedly accounts for the severe complications associated with this drug. While nitrous oxide oxygen has been used extensively in the office, especially by the dentist, the trend today is away from the use of nitrous oxide as the sole anesthetic. Realizing its limited potency, nitrous oxide is now used in combination with other drugs of greater potency, such as ethyl ether, vinyl ether, thiopental and trichlorethylene. Such combinations increase potency without encroaching upon oxygen content and greatly increase the safety of the agent. For instance, when combining nitrous oxide-oxygen with ethyl ether, a concentration of 50 per cent nitrous oxide and 50 per cent oxygen may be used while obtaining adequate depth of anesthesia.

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depth of anesthesia may occur rapidly. If attempts are made to hurry the induction and "push" the drug too rapidly, muscular twitchings and even convulsions may result. This is more apt to occur in the unpremedicated patient. Ideally, the routine use of atropine preoperatively is desirable; in practice, however, it is omitted many times. *Induction should not be hurried.* The potential hepatotoxic effects of vinyl ether may be expected only after prolonged administration (1 hour) of the drug and are not a factor to be considered here. The use of vinyl ether in the adult patient has been *almost completely discarded* in favor of intravenous thiopental.

Ethyl Chloride

Ethyl chloride is a very potent, highly volatile anesthetic agent which produces loss of consciousness without marked excitement. It is marketed in compression tubes and used as a spray on an open drop mask covered with gauze. It is never administered by an anesthesia machine. Induction and recovery are rapid. Nausea and vomiting are minimal. This agent most nearly *approximates chloroform in its actions*, but, also like chloroform, it is dangerous because of its extreme potency and the circulatory depression which it produces. Its use must be confined to the experienced administrator, and even then the scope of its use should be restricted to very short operations or as an agent to induce anesthesia prior to the administration of ethyl ether. While this drug is superior in many respects to vinyl ether, its margin of safety is very small and its use hazardous in the ambulatory patient.

Ethyl Ether (Diethylether, Ether)

While ethyl ether is a safe, dependable and long-tried anesthetic agent, its use in the ambulatory patient is quite limited. The vapor is very irritating, making induction slow. The incidence of nausea and vomiting is high. Recovery is protracted. Its greatest value might be as a maintenance agent in surgery which lasted longer than expected, where anesthesia initially consisted of vinyl ether or nitrous oxide. If ethyl ether is administered to the ambulatory patient, sufficient time must be permitted for full recovery from the anesthesia.

LOCAL ANESTHESIA

The ability to interrupt nerve conduction with facility, and thus produce anesthesia by the appropriate use of a local anesthetic drug, has permitted an almost unrestricted variety of surgery to be safely and painlessly performed in the ambulatory patient. Many local anesthetic drugs have been given a clinical trial, each with the hope that it would prove to be the ideal local anesthetic. Thus far, this ideal drug has not been introduced. The *ideal local anesthetic drug should possess* the following properties:

1. It should be capable of producing anesthesia when applied topically, when used for infiltration anesthesia, and when injected round a nerve for nerve block or plexus block.

2. It should possess a wide margin of safety so that effective clinical doses do not closely approximate toxic doses.

3. It should have a selectivity of action confined to nerve tissue.

4. It should possess low toxicity in doses employed clinically. It should not produce deleterious effects on tis-

sues at the site of injection, nor should it produce systemic toxicity following its absorption from the point of administration.

5. It should produce rapid onset of anesthesia.

6. It should ensure anesthesia of sufficient duration to permit completion of surgery.

7. It should be completely reversible in its effects. Complete restoration of nerve conduction should occur when absorption of the drug is complete.

8. It should be stable so that decomposition will not occur with sterilization and exposure to air.

9. It should be readily soluble in saline or distilled water.

Local Anesthetic Agents

While many local anesthetic agents have been introduced and advocated for clinical use, only a few are presently accepted and widely used.

Cocaine Hydrochloride

Cocaine hydrochloride was the first local anesthetic drug employed clinically.[6] Its use for infiltration and nerve-block anesthesia has long been discarded because of the severe toxic reactions which it produces. Cocaine hydrochloride still is widely employed as a topical anesthetic agent and is considered to be superior to other drugs for this form of anesthesia. A few drops of a solution of 4 per cent cocaine hydrochloride repeatedly instilled into the conjunctival sac will produce complete corneal anesthesia. Repeated instillations may produce desquamation of the cornea. For this reason, cocaine has been replaced by Pontocaine (0.5%) for topical corneal anesthesia. More concentrated solutions of cocaine hydrochloride (5 to 20%) are used by the otolaryngologist to produce topical anesthesia of the nasal mucosa, the pharynx and the larynx. Cocaine not only produces topical anesthesia but also constricts blood vessels, shrinks the nasal mucosa and decreases bleeding.

Cocaine hydrochloride should not be used on large mucous membrane surfaces, such as the bladder; nor should it be used when denuded areas are present on mucous-membrane surfaces.[25] Rapid absorption of large doses of cocaine results, leading to serious reactions and death. A total of 1 Gm. of cocaine never should be exceeded at any one administration.

Procaine Hydrochloride (Novocain)

Procaine hydrochloride remains the most valuable local anesthetic drug available for use in the ambulatory patient. Although introduced in 1905, it continues to be the yardstick for all other local anesthetic drugs. Procaine has its shortcomings. It is not an effective topical anesthetic when used in safe concentrations. It does not produce prolonged anesthesia. Its action is relatively short (½ to 1 hour). However, this time period is more than adequate for the majority of office surgical procedures. Procaine has survived the test of extensive clinical trial. It may be used for infiltration anesthesia (0.5%), nerve block (1 to 1½%) or plexus block (2%). Onset of anesthesia is relatively rapid. The effect of the drug is fully reversible. Sterile solutions of procaine are easily and conveniently prepared. Research in many new anesthetic agents has not produced a drug superior to procaine hydrochloride.

Pontocaine Hydrochloride (Tetracaine)

Pontocaine hydrochloride is an excellent local anesthetic drug which may be used for topical infiltration, nerve block or spinal anesthesia. It possesses 10 to 15 times the potency of procaine, so that when employed for local anesthesia one tenth the estimated dose of procaine is used. This scaled-down dose decreases the toxicity of the drug. Many investigators are of the opinion that Pontocaine is even less toxic than procaine[8] The real advantage of Pontocaine lies in its duration of action. When used for regional anesthesia in combination with a vasoconstrictor drug, anesthesia lasting from 4½ to 5 hours may be obtained. However, unless a long-lasting local anesthetic block is desired, a drug with effects of such long duration is actually a disadvantage in office practice. As an 0.5 to 2 per cent solution it is also being used more and more as a topical anesthetic replacing cocaine. However, in this capacity, it has produced a number of fatal toxic reactions, which have retarded the more widespread acceptance of this agent.

Xylocaine (Lidocaine)

One of the more recent and most promising local anesthetic drugs to be introduced to clinical anesthesia is Xylocaine hydrochloride.[19] This drug possesses all the advantages of procaine, and, in addition, it is an excellent topical anesthetic; its effects come on more quickly and its duration of action is longer. The toxicity of Xylocaine is no greater than that of procaine. It may be substituted for procaine in those cases with a history of procaine sensitivity. This drug is far more costly than procaine without sufficient additional advantages over procaine to justify its complete adoption.

Nupercaine Hydrochloride (Percaine)

Nupercaine hydrochloride is the longest lasting of the local anesthetic drugs. Its duration of action is approximately from 2½ to 3 hours. The toxicity of Nupercaine is between 10 and 15 times greater than that of procaine. However, since the potency of the drug is 15 times greater than that of procaine, it may be used in greatly reduced dosage with excellent clinical effects. Concentrations of Nupercaine as dilute as 0.05 per cent are sufficient to produce block of the sciatic nerve. Nupercaine is an excellent topical anesthetic drug and is marketed as an ointment for treatment of various painful lesions of the skin. It is not used frequently for other types of regional anesthesia unless a block of maximum duration is desired. It is an excellent spinal-anesthetic agent producing anesthesia of from 2½ to 3 hours' duration. Oily solutions of Nupercaine (0.5 % Nupercaine with benzyl alcohol in almond oil) have been employed to produce long-lasting anesthesia. The use of these solutions has been discarded generally because of the local tissue necrosis which has resulted.

Metycaine Hydrochloride

Metycaine hydrochloride has been found to be useful in all types of regional anesthetic procedures, including local infiltration, nerve and plexus block and spinal anesthesia. It is a good topical anesthetic also.

Next to procaine, Metycaine has been used most extensively in this country for regional anesthesia. While it is slightly more toxic than procaine[6,29,50] when administered in equal

dosage, its greater potency permits the use of less concentrated solutions than procaine for clinical anesthesia. Metycaine has been widely used in obstetrics for caudal anesthesia. Since Metycaine is not related to procaine chemically, it may be used in patients with suspected procaine sensitivity. For infiltration anesthesia, ½ per cent Metycaine is used; for nerve block, from 1 to 1½ per cent is employed

Other Agents

Although many other local anesthetic agents have been used clinically, none possesses such distinct advantages over those previously discussed to warrant its general acceptance and consideration. Individual drugs may be used according to the preference and the experience of the surgeon. One cannot be too cautious in the use and the acceptance of any new procaine substitute until its pharmacologic action and toxicity have been thoroughly investigated.

Long-Lasting Anesthesia Preparations

In an effort to obtain a local anesthetic with long duration of action which would be of value in the management of various types of pain syndromes, many preparations of drugs have been marketed. These usually have consisted of a solution of a local anesthetic base in various vegetable oils, such as oil of sweet almonds, peanut oil or corn oil. In addition, other drugs with prolonged anesthetic effects, such as benzyl alcohol, are added to the solution. Procaine, Nupercaine, Intracaine, Diothane and benzocaine have been used most frequently as the anesthetic base in these preparations. While in theory the concept of a long-lasting local anesthetic preparation is good, in practice the use of these preparations has been most unreliable in relieving pain for prolonged periods and, in addition, has produced serious local toxic changes at the site of injection.

More recently, preparations have been introduced substituting a water-miscible and nontoxic organic solvent for the vegetable oils[2] which previously had been used as the vehicle for the local anesthetic. The results obtained by the use of these preparations have been most unreliable. Local tissue reaction has been reported at the site of injection. Neuritis may be a complication following nerve block.[27] The use of these preparations has now been abandoned.

Adjuncts to Local Anesthetics

Vasoconstrictors are added to solutions of local anesthetic drugs (1) to prolong and intensify the anesthesia,[6] (2) to permit the use of smaller concentrations of the local anesthetic agent, (3) to decrease the rate of absorption of the drug, and (4) to reduce the incidence of toxic reactions. Epinephrine is the most effective vasoconstrictor employed with local anesthetics. The hydrochloride salt is most frequently used. It is marketed in 1-cc. ampules containing 1 mg. (1:1,000) and in 10- and 30-cc. bottles containing 0.1 per cent solution (1 mg./cc.). When used in proper concentration, the injection of epinephrine causes local vasoconstriction at the site of injection. However, if larger amounts of epinephrine are used with the local anesthesia solution, systemic toxic effects will be manifested. These reactions consist of tachycardia, palpitation, hypertension, headache, anxiety, restlessness, faintness, apprehension and tremor—all signs of excessive sympathetic activity. These reactions often

are misinterpreted as being toxic manifestations of the local anesthetic rather than the vasopressor agent. This is seen frequently in patients who have dental extractions performed under local anesthesia. Large amounts of epinephrine are added to dental preparations of local anesthetic drugs. If a patient gives a history of such a reaction, it must be ascertained whether it was caused by the vasopressor drug or the local anesthetic. It is the belief of many that a reaction to epinephrine is far more common than a true local anesthetic drug reaction.[7]

Optimum Concentration

Numerous investigators have demonstrated that the optimum concentration of epinephrine to be added to a local anesthetic solution is 1:200,000 in the final dilution.[6,9] This amounts to 1 cc. of 1:1,000 solution (1 mg.) of epinephrine for every 200 cc. of solution. The use of a more concentrated solution of epinephrine (1:50,000) does not further retard procaine absorption[44] and leads only to a higher incidence of toxic vasopressor reactions. When adding epinephrine to a solution, it is best to use a 1-cc. tuberculin syringe to obtain accurate amounts rather than a larger syringe, which frequently delivers more drug than is necessary and produces overdosage of vasoconstrictor agent. Epinephrine should not be used in patients sensitive to the drug, in patients with thyrotoxicosis or in those patients having any type of occlusive vascular disease. It should be used with caution in patients with hypertensive cardiovascular disease or coronary artery disease. Many workers do not advocate its use in blocking the fingers or the toes.

Cobefrin

Cobefrin is a vasoconstrictor drug less potent than epinephrine and producing fewer untoward reactions. It is about one fifth as potent as epinephrine and, therefore, is used in a final dilution of 1:40,000. However, even with this concentration, the prolongation of action of the local anesthetic is not as long as with epinephrine.[6] Because of the lower incidence of reactions produced by Cobefrin, it has been used frequently for the cardiac patient.

Hyaluronidase

Hyaluronidase, first described as the "spreading factor" of Duran-Reynals,[15] is an enzyme capable of hydrolyzing hyaluronic acid, a viscous polysaccharide forming the interstitial cement substance. With the hydrolysis of this interstitial substance, the diffusion of injected solutions is greatly facilitated. Hyaluronidase has been used in conjunction with local anesthesia in an effort to increase the number of successful blocks and to hasten the onset of anesthesia. Various investigators[23,36] have found that the addition of 150 turbidity reducing units of hyaluronidase to 30-cc. solution (1) markedly shortens the onset of anesthesia, (2) decreases the duration of anesthesia, especially if epinephrine is omitted, (3) increases the incidence of toxic reactions to local anesthetic agents and the vasoconstrictors, and (4) does not increase the percentage of successful blocks. These effects are due to the more rapid absorption of the local anesthetic solution due to greater and more rapid diffusion through the tissues. The drug is marketed in vials containing 150 T.R.U. (turbidity reducing units). It is nontoxic, even when administered in far greater con-

centrations than are employed clinically. Hyaluronidase may have a limited usefulness for the ambulatory patient.

Toxicity of Local Anesthetic Agents

Although the many local anesthetic drugs employed clinically are unrelated chemically, all are capable of producing a similar toxic response when absorbed systemically in excessive amounts. These drugs initially produce stimulation of the central nervous system from cortex to medulla. Cortical stimulation is manifested as confusion, irrationality, talkativeness, apprehension, un-co-operativeness, hallucinations, headache and emotional instability. Muscular twitchings develop, ranging from chronic localized twitchings to generalized toxic convulsions. Medullary stimulation produces increased rate and depth of respiration, tachycardia, rise in blood pressure, nausea and vomiting. This stimulatory phase of the toxic reaction is brief and rapid and is followed by the second, or paralytic, phase. The patient becomes lethargic and loses consciousness. Respiration becomes shallow and fails completely. The patient becomes pulseless and without blood pressure; cardiovascular failure follows. Cyanosis is intense. Pupils are widely dilated, and the eyeballs are fixed. Sphincter control is lost. Death ensues quickly. All gradations of severity of this reaction may occur. The reaction may be confined to mild central-nervous-system stimulation and may terminate spontaneously, or it may produce muscular twitchings or convulsions and then cease. It is impossible to predict how far the reaction will progress, so that as soon as symptoms of toxicity develop, the patient must be treated as though a severe reaction will follow. In some patients, especially the aged, only the depressive phase of the reaction may be seen. The first manifestation of toxicity may be unconsciousness, hypotension and a weak, slow pulse. The incidence of these reactions is not known. Many are so mild that they are unrecognized. Others attributed to the local anesthesia are in reality due to the vasopressor drug.

Cause of Reactions

1. *Administration of too much drug* (overdosage). The maximum safe dose of procaine administered at any one time is 1 Gm. although individual tolerance varies widely.

2. Inadvertent intravascular injection of the drug

3. Injection of excessive doses of local anesthesia into highly vascular areas with rapid absorption of the drug into the blood stream.

4. Use of concentrated solutions of local anesthetics. (Many anesthetists feel that the toxicity of procaine is represented not by a direct but by a geometric ratio to its concentration.[44]

5. The injection of a therapeutic dose of a local anesthetic in a sensitive patient (true drug idiosyncracy).[18] This is rare.

Prophylaxis of These Reactions

Since a toxic reaction to a local anesthetic may be fatal, it is imperative that all measures be taken to prevent their occurrence. These are practical measures which should be familiar to all physicians using local anesthesia:

1. Confine the total injected drug to safe doses (maximum dose 1 Gm. procaine).

2. Administer preoperatively a short, rapid-acting barbiturate. It has been shown that barbiturates, being

are misinterpreted as being toxic manifestations of the local anesthetic rather than the vasopressor agent. This is seen frequently in patients who have dental extractions performed under local anesthesia. Large amounts of epinephrine are added to dental preparations of local anesthetic drugs. If a patient gives a history of such a reaction, it must be ascertained whether it was caused by the vasopressor drug or the local anesthetic. It is the belief of many that a reaction to epinephrine is far more common than a true local anesthetic drug reaction.[7]

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direct cortical depressants, counteract the cortical stimulative effects of local anesthetics.[47] Pentobarbital (0.1 Gm.) given ½ hour before surgery is sufficient.

3. Add epinephrine hydrochloride (1:200,000) to the local anesthetic solution.

4. Avoid intravascular injection by frequent aspiration prior to injection.

5. Use care when injecting drugs into highly vascular areas.

6 Evaluate the patient carefully. Cachetic, debilitated and aged patients must be given a reduced amount of local anesthetics.

7. Observe constantly and keep verbal contact with the patient during and following the administration of local anesthesia. Blood pressure, pulse and respiration should be noted at frequent intervals.

8. Question patients thoroughly concerning previous surgery under local anesthesia. If a patient gives a history of a reaction, efforts should be made to determine the presence of sensitivity to procaine. This may be done by raising an intradermal wheal with procaine or instilling a few drops of procaine into the conjunctival sac. A positive response indicates procaine sensitivity. However, a negative response does not rule out possible sensitivity.

Treatment of Toxic Reactions

The salvaging of a normal patient following a toxic local anesthetic reaction depends upon the immediate diagnosis of the condition and the prompt institution of definitive therapeutic measures. Failure to act promptly may make the difference between life and death. The following measures should be taken:

1. Administer 100 per cent oxygen by face mask and breathing bag. If respiratory failure develops, artificial respiration must be instituted through a patent airway.

2. Start venoclysis, using 5% dextrose in distilled water.

3. Administer vasopressor agents, such as neosynephrine, ephedrine or methoxamine, to combat hypotension. It is best to prepare a dilute solution of a pressor drug (10 mg. neosynephrine in 1,000 cc. 5% dextrose) to be administered by constant intravenous infusion.

4. If the patient is convulsing or twitching, inject intravenously a rapid-acting barbiturate, such as thiopental sodium (Pentothal). Usually, from 100 to 200 mg. of Pentothal is adequate to control already-existing convulsions. If, however, the patient is not convulsing and has lost consciousness, a barbiturate never should be injected.

5. If the patient develops cardiovascular collapse and cardiac arrest, carry out thoracotomy and start cardiac massage immediately. Cardiac arrest is a real danger with this type of reaction.

TECHNIC FOR LOCAL ANESTHESIA

The equipment necessary for local anesthesia need not be elaborate, but it must be kept in good condition at all times. Glass syringes of 5-cc. and 10-cc. capacity, with metal tips so designed that the needles may be firmly locked in place, are the most satisfactory but are not essential. Metal rings for the fingers, permitting a firmer grip and better control of the syringe, are preferred (Fig. 15).

Needles must be carefully selected. A 25-gauge ¾-in. needle with a sharp, beveled point is used for the initial skin wheal or endermic infiltration. A

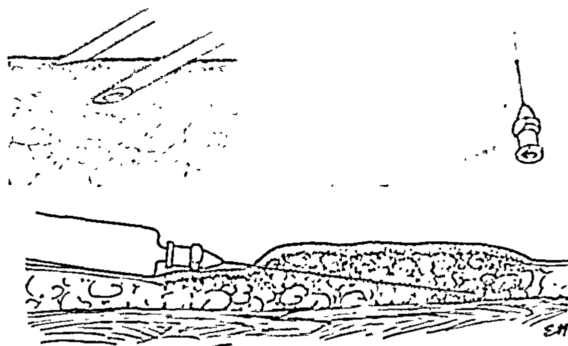


FIG. 20 (*Top, left*). The initial skin wheal is made by the short 25-gauge needle. The needle is inserted with the bevel parallel to the skin surface, and the anesthetic solution is injected as the needle is carried through the skin tissues. In this way there is little discomfort associated with the injection.

FIG. 21 (*Top, right, and bottom*). Infiltration of the deeper tissues is carried out with the long needle, which is always inserted through skin areas that have previously been anesthetized. Injection of the anesthetic solution is made as the needle advances.

selection of 22-gauge needles of 2, 3 and 4 in. should be available for deep infiltration and nerve blocks.

Syringes and needles must be cleansed thoroughly after use and sterilized for subsequent use.

Local Infiltration

Local anesthesia is produced most commonly by the direct infiltration of the tissues with the anesthetic solution. Thus, suitable anesthesia may be obtained for superficial tumors, cysts, thrombosed external hemorrhoids and a number of other superficial lesions. Acute fractures may be reduced easily after the direct infiltration of the hematoma about the fracture site with the anesthetic solution. Superficial infections, contrary to general opinion, may be opened under local anesthesia by infiltration of the skin along the line of the proposed incision without fear of spreading the infection. Ádám[1,2] agrees with this view.

Procaine hydrochloride 0.5 per cent or Metycaine 0.25 per cent is used for local infiltration for removing superficial lesions, suturing small wounds, skin grafting and incising superficial abscesses. An initial skin wheal is first made, using the small 25-gauge hypodermic needle. The point of the needle is inserted with the bevel down

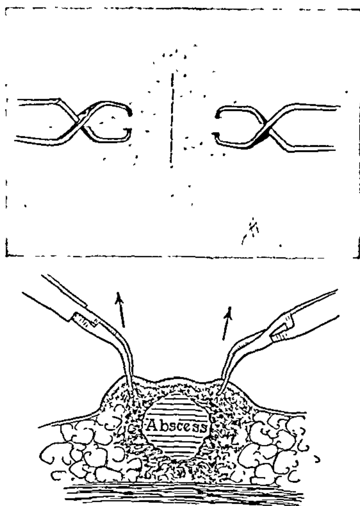


FIG. 22. Method of incising a superficial abscess under local infiltration anesthesia. *The skin and the* superficial tissues overlying the abscess cavity are infiltrated in the usual manner. Towel clips are inserted into the anesthetized skin on either side of the proposed line of incision. An assistant lifts the towel clips *up as the incision is made* into the cavity. In this way pressure on the abscess by the knife during the incision is avoided, as is also the severe pain which accompanies such pressure. Following incision of the abscess, the towel clips on *the wound edges may* be used as retractors to aid in exposing the cavity.

directly into the skin (Fig. 20). In places where the skin is loose, it should be held under tension during this injection. *The anesthetic solution is injected* as the needle is inserted into the skin. Thus a cutaneous wheal, which should be about 1 cm. in diameter, is produced with little or no pain to the patient Then a longer needle is attached to the syringe, inserted through the anesthetized skin at the site of the wheal, and a subcutaneous linear or elliptical line of infiltration is produced; or the intradermal infiltration may be continued from the original wheal (Fig. 21). When the *infiltration is to be continued* subcutaneously, it may be necessary to make more than one cutaneous wheal; or, better still, the longer needle may be inserted into the cutaneous layer from beneath, at the end of the subcutaneous infiltration, a wheal produced, and the subcutaneous infiltration continued further by reinserting the needle through this wheal.

Infiltration of the skin along the line of proposed incision of a superficial abscess will not spread the infection if adequate drainage is obtained, and the abscess may be opened with no discomfort to the patient if pain produced by pressure is prevented. Mabry[31] has described a *method which permits incision and* drainage of superficial abscesses with

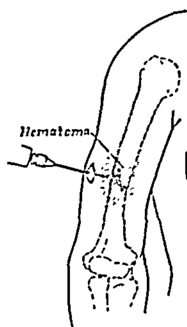


FIG. 23. Local anesthesia in the reduction of fractures. The long needle is inserted through an initial skin wheal until bloody fluid can be aspirated or the tip of the needle itself slips between the bony fragments. The anesthetic solution is then injected into the hematoma at the fracture site.

no discomfort to the patient. After the skin has been anesthetized it is grasped with a towel clip or between 2 towel clips and lifted up while the incision is made (Fig. 22). Thus deep pressure over the inflamed area is avoided, and painless incision can be performed, since the skin has been anesthetized. No epinephrine is used in the anesthetic solution.

Anesthesia for the reduction of acute fractures of any of the bones of the extremities may be obtained readily by the direct infiltration of a local anesthetic solution at the fracture site (Fig. 23). The longer 2- or 3-in. needle is introduced through one or more skin wheals toward the fracture line, avoiding as far as possible the larger vessels and nerves. After contacting the bone, the needle may be partially withdrawn and reinserted until aspiration of bloody fluid indicates that the hematoma about the fracture has been reached. Occasionally, one may be able to feel the needle slip between the bone fragments at the line of fracture. The fact that bloody fluid may be aspirated at several levels indicates that the hematoma has been pierced, rather than that an accidental venipuncture has been performed. The blood aspirated from a hematoma of several hours' duration may also be identified by its dark appearance.

Procaine hydrochloride in 1 or 2 per cent solution, preferably with epinephrine, is used for the infiltration about a fracture. Not more than 30 cc. of the 2 per cent solution or more than 60 cc. of the 1 per cent solution should be used routinely, and the injection always should be performed slowly and cautiously in order to avoid systemic reactions. Full anesthesia is not obtained until at least 15 minutes after the injection.

The best results with infiltration anesthesia for the reduction of fractures are obtained with early, acute fractures. After from 48 to 72 hours, the hematoma about the fracture site becomes organized, making it more difficult to obtain satisfactory infiltration. However, this anesthesia may be used with almost any fracture of less than 48 hours' duration and is the most efficient anesthesia in such cases. Reduction may be performed safely under fluoroscopic guidance and the full co-operation of the patient maintained throughout the procedure; this greatly facilitates the reduction and the subsequent application of splints or plaster casts for immobilization. It is a distinct advantage in the reduc-

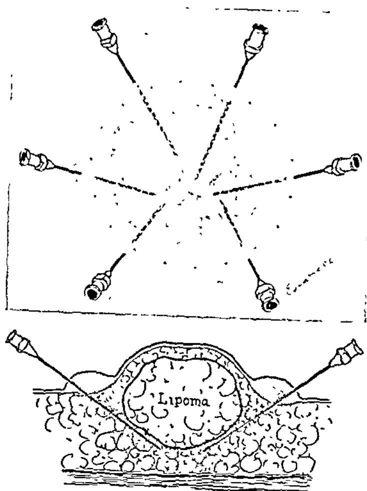


FIG. 21. Field block. By inserting the long needle through the initial skin wheal a complete wall of the anesthetic solution is infiltrated round the operative field. In this way all sensory impulses from the operative site are blocked without actual infiltration in the field or distortion of tissues.

tion of fractures in a dark fluoroscopic room and at times when an anesthetist is not available. It is the anesthesia of choice for the reduction of fractures in ambulatory patients.

Field Block

Diffuse infiltration of an anesthetic solution through all tissues containing sensory nerves leading from the field of proposed operative intervention effectively blocks sensory impulses in these nerves and their branches. Anesthesia of the operative field is thus produced without direct infiltration at the operative site. This is known as field-block anesthesia and is an intermediate procedure between purely local infiltration and nerve block. A wider zone of anesthesia, which usually lasts longer, may be obtained with smaller quantities of anesthetic solution than would be required for local infiltration of the entire operative field. In addition, it requires less technical skill than nerve block and therefore may be used to advantage when the operative site is supplied by a number of small sensory nerves.

A field-block type of anesthesia may be preferred to direct local infiltration for the removal of sebaceous cysts, lipomas, benign tumors and other superficial lesions of the body surface, as the tissues at the site of operation are not distorted by infiltration with the anesthetic solution. The anesthetic solution is injected into th[illegible] and th[illegible]

subcutaneous tissues through an initial skin wheal to form an elliptical or diamond-shaped zone of infiltration round the operative field. Procaine hydrochloride 0.75 or 1 per cent or Metycaine 0.5 per cent should be used for this type of anesthesia (Fig. 24).

The Scalp. Anesthesia of the scalp may be obtained by a zone of infiltration encircling the lesion, since all the sensory nerves pass upward in the subcutaneous tissues. Thus any portion of the scalp may be anesthetized conveniently by a field block with 0.5 to 1 per cent procaine hydrochloride (Fig. 24).

The Neck. The majority of operations about the neck on ambulatory patients may be accomplished by the use of local infiltration anesthesia. Deep cervical block, which may be used for more extensive operations, is not indicated, although superficial cervical block, a form of field-block anesthesia, may be useful occasionally in conjunction with local infiltration. The superficial branches of the cervical plexus may be blocked as they cross over the posterior border of the sternocleidomastoid muscle by the subcutaneous injection of 20 to 30 cc of 0.5 per cent procaine. The injection is made deep to the external jugular vein but directly overlying and along the posterior edge of the muscle[15] (Fig. 25).

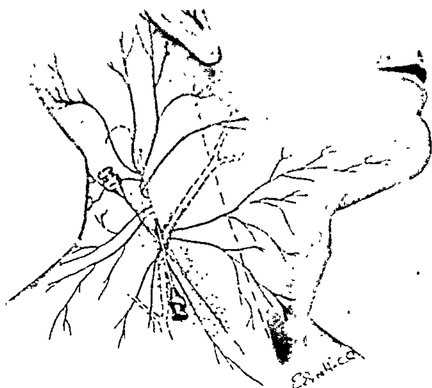


Fig. 25. [illegible]
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ster[illegible] The long needle is inserted through an initial skin wheal, and the injection is made deep to the external jugular vein but directly overlying and along the posterior edge of the muscle.

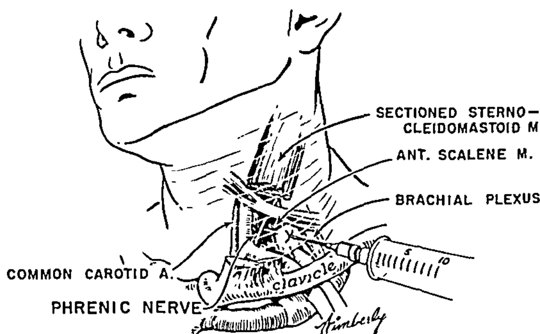


FIG. 26 Phrenic nerve block. The phrenic nerve may be blocked as it crosses *over the anterior scalenus muscle. Injection is made 3 cm. above the clavicle on* the posterior border of the sternocleidomastoid muscle The needle is inserted to a depth of 1½ in or until it pierces the fascia of the scalenus anticus muscle.

Phrenic Nerve Block

Phrenic nerve block is one of the most useful and practical therapeutic blocks for the treatment of intractable hiccups and may be of value in the ambulatory patient. The phrenic nerve arises from the anterior primary division of the fourth cervical nerve and receives fibers from the third and the fifth cervical nerves. The 3 components join together and descend as the main nerve trunk, crossing over the anterior scalenus muscle. The nerve may be blocked as it crosses the anterior surface of the muscle. With the patient in the supine position and head turned to the opposite side, the posterior border of the sternocleidomastoid muscle is palpated with the index finger. A skin wheal is raised 3 cm above the clavicle on the posterior border of the sternocleidomastoid muscle. The anterior scalenus muscle is situated lateral and posterior to the sternocleidomastoid. A 22-gauge short beveled needle is inserted through the wheal and advanced posteromedially until the fascia of the anterior scalenus muscle is pierced. This is usually at a depth of 1½ in From 10 to 15 cc. of a 1 to 2 per cent solution of procaine with or without epinephrine is injected slowly. Anesthesia is established in 10 to 15 minutes.

The Thoracic Wall. Any desired area on the thoracic wall may be blocked widely by infiltration of all the layers with the anesthetic solution. In addition to the tissue infiltration, the intercostal nerves may be

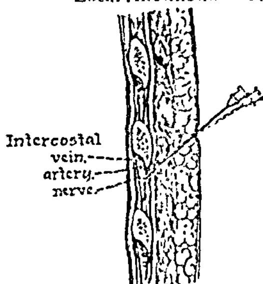


FIG. 27. Intercostal nerve block. The dotted figure shows the position of the needle as it is introduced through a cutaneous wheal until the rib is contacted. The needle then is withdrawn slightly and reintroduced so that it passes just beneath the lower border of the rib. At this point the anesthetic solution is injected.

blocked by depositing 3 to 5 cc. of the anesthetic solution beneath the lower border of each rib. A 2-in. needle is introduced through a cutaneous wheal until the rib has been contacted; then the needle is withdrawn slightly and reintroduced until it passes beneath the lower border of the rib. Aspiration is performed to be certain that a vein has not been punctured, and then the anesthetic solution is injected (Fig. 27).

The Abdominal Wall. Anesthesia of the upper abdomen may be obtained by an intercostal block in the anterior axillary line, from the fifth or the sixth interspace down; or the intercostal nerves (seventh to twelfth) supplying the abdominal wall may be blocked by infiltration of the anesthetic solution beneath the fascia along the costal border. If the ilio-inguinal and the iliohypogastric nerves are also blocked by infiltration below the external oblique aponeurosis just mesial to the anterior iliac spine, anesthesia of the entire abdominal wall is obtained.

The Perineum. Lundy and Tuohy recommend a simple type of injection for anesthesia of the perineum which is useful in operative obstetrics: "When the patient is in the lithotomy position, the injection of 10 or 15 cc. of a 1 per cent solution of procaine or Metycaine just mesial to the tuberosities of the ischia will produce anesthesia of the anterior half of the perineum which will last for more than half an hour. This injection may be repeated from time to time if necessary. This produces anesthesia of the labia and urethra but not of the anus. However, this block may be supplemented by the injection of very small amounts of 0.5 per cent procaine or Metycaine at the points at which tenderness occurs, if necessary."[30]

Caudal block anesthesia should be used for more extensive operations about the perineum, particularly if the rectum is to be included in the field.

The Penis. Block anesthesia for circumcision or other operations on the penis may be obtained by a subcutaneous injection encircling the base of the penis, supplemented by the in-

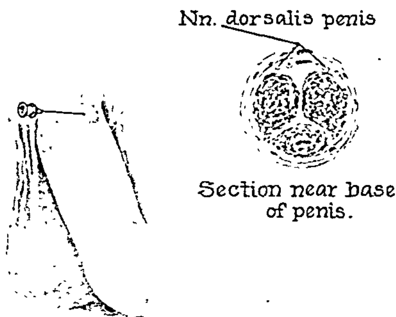
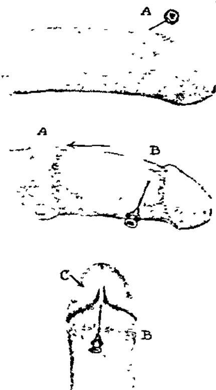


Fig. 28 Block anesthesia of the penis. The nerves of the penis may be blocked by a subcutaneous injection encircling the base of the penis. The cross section shows the dorsal nerves of the penis beneath Buck's fascia, which must also be blocked by the injection beneath the fascia of 1 or 2 cc. of the anesthetic solution.

Fig. 29. Technic of local infiltration anesthesia for circumcision. The foreskin is reflected over the glans and a circle of the anesthetic solution is infiltrated subcutaneously at the level of the base of the glans at (A). The foreskin is retracted and a circle of the anesthetic solution is deposited under the skin close to the edge of the glans at (B). Special care must be taken to infiltrate the frenum and its sensory nerve (C).



jection of 1 to 2 cc. of the solution beneath the fascia (Buck's) on each side. Procaine solution of 1 or 2 per cent should be used (Fig. 28).

For circumcision, a simple form of *infiltration anesthesia is practiced* more commonly. With 1 per cent procaine solution, the foreskin is reflected, and a circle of infiltration anesthesia is deposited under the skin, close to the edge of the glans. Special care must be taken to infiltrate the frenum, in which there is a rich plexus of sensory nerves. After this infiltration has *been completed, the foreskin is replaced* over the glans, and a second circle of infiltration is made in the skin at the same level at the base of

the glans. This dual infiltration is not time consuming and gives excellent anesthesia. In cases in which the foreskin cannot be retracted easily (Fig. 29), the superficial skin anesthesia is induced first, and then the anesthetic is carried deeper into the foreskin near the edge of the glans. A line of infiltration is injected downward to the edge of the foreskin. With this anesthesia it is possible to incise the edge of the foreskin sufficiently to permit retraction and the completion of the anesthesia.

The Anus and the Rectum. The sensory nerves which go to the anal canal and the anal orifice may be blocked easily, as they traverse the fatty tissues of the ischiorectal fossa. These nerves arise from the perineal nerve as it passes in Alcock's canal along the ramus of the pubis. They traverse the ischiorectal fossa from behind, forward and mesially, to reach the anal canal. In addition, there are a few small so-called coccygeal nerves which pass directly forward from the region of the coccyx to the anal canal. Therefore, it is possible to block completely all the nerves which reach the anal canal by introducing a wall of anesthetic solution outside it in the ischiorectal fossa (Fig. 30).

This is accomplished best with 2 injections. The first is an infiltration anesthesia into the skin of the perianal region, usually performed with 1 per cent procaine solution containing

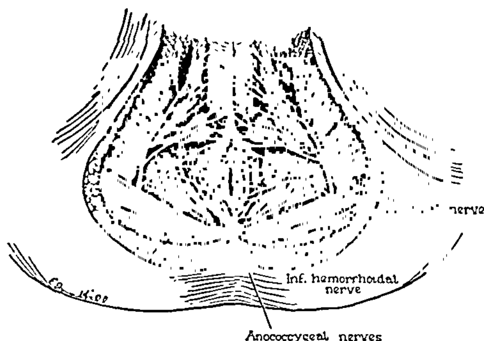


Fig. 30. Nerve supply of the perineum. Branches of the inferior hemorrhoidal and perineal nerves cross forward and mesially from the lateral wall of the ischiorectal fossa In addition, a few sensory fibers pass directly forward from the region of the coccyx. To block the nerves of this region, therefore, it is important that most of the anesthetic solution be deposited round the posterior half of the circumference of the anal canal. (Ferguson, L. Kraeer: Clin. North America 19:1513-1524)

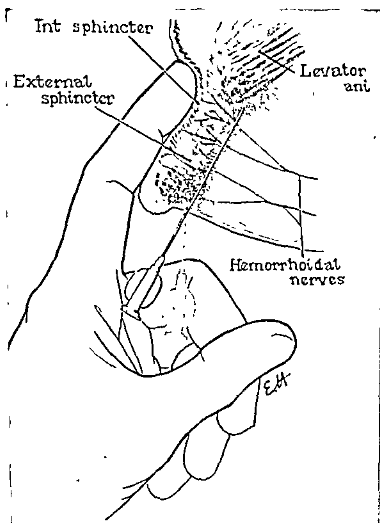


FIG. 31. Technic for block of the nerves to the anal region. Following local infiltration of the skin of the perianal region a deeper injection is made to block the sensory nerves as they cross the ischiorectal fossa With the index finger of the left hand in the anal canal as a guide, the long needle is inserted into the midline posteriorly, and the injection is carried out in a fanlike direction on either side of the anal canal and about 1 in. from it. (Ferguson, L. Kraeer: S Clin North America 19:1513-1521)

epinephrine. It may be injected without fear of subsequent infection if the area has been cleaned with soap and water and followed by the application of one of the commonly used antiseptic solutions. We never have seen an infection arise from a local infiltration anesthesia for an operation on the anal canal. As a rule, the local infiltration is begun at the mid-line posteriorly and is carried laterally on each side to anesthetize completely the skin surrounding the anal orifice.

After the introduction of the skin infiltration, a deeper injection must be made to block the nerves as they traverse the ischiorectal fossa. Since these nerves pass from behind, forward and mesially, it is most important that the anesthetic solution be introduced round the posterior half of the circumference of the anal canal. With the index finger of the left hand introduced through the anal orifice (Fig. 31), the injection is begun just to the lateral side of the mid-line. The patient should be warned of some slight feeling of discomfort as the needle is introduced deeply into the ischiorectal fossa. Failure to give this warning may cause the patient undue apprehension, and, if he moves, considerable diffi-

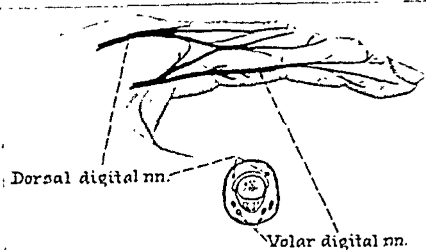


FIG. 32. Digital nerve block. Operations on the fingers and the toes may be performed by blocking the digital nerves. The needle is inserted through intradermal wheals at the base of the digit, and the anesthetic solution is deposited in the region of the dorsal and the volar digital nerves shown in the figure.

culty may ensue, even to puncturing the anal canal or the rectum with the needle. The needle is carried in a fanlike direction round the anal canal, forward and backward. The injection is made at a distance of about 3/4 in. to 1 in. away from the canal, the nerves being blocked as they approach the canal itself. It should be carried throughout the entire length of the anal canal, about 20 cc. of 1 per cent procaine or, better, of 1 per cent Metycaine being used on each side. Occasionally, it is necessary to make an anterior injection, but this is not always necessary.

In making these injections into the ischiorectal fossa for block of the nerves to the anal canal, it is important that only a small amount of the solution be deposited in one place. The needle must be kept moving practically all the time and the injection made continuously. If too much solution is deposited at any one place, a painful slough may result.

The local infiltration produces almost immediate anesthesia and causes relatively slight distortion. The addition of epinephrine, 5 drops of the 1:1,000 solution to the ounce of anesthetic solution, not only prolongs the anesthetic effect but also markedly reduces the amount of bleeding. This type of anesthesia is especially valuable for anal-fissure operations, hemorrhoidectomy, the removal of anal polyps and anal crypts. It may be contraindicated in infected areas, such as abscesses and complicated fistulas. We have used it frequently for anal operations in ambulatory patients with no ill results. During a 2-year period, local anesthesia has been used for 222 operations on ambulatory patients as follows: hemorrhoidectomy, 62; fistulectomy, 23; incision of ischiorectal abscess, 16; excision of fissure in ano, 117; and excision of anal polyps, 4. The incidence of postoperative urinary retention following anal operations is less after local infiltration and block anesthesia than after any of the other anesthetics used for anal operations.

Nerve Block (Conduction Anesthesia)

Anesthesia within the area of distribution of a sensory nerve may be produced by the injection of an anesthetic solution into or immediately round the nerve or a plexus of nerves.

The chief advantage of nerve block anesthesia is that long-lasting anesthesia is obtained over a comparatively large area with a minimal amount of anesthetic solution. Its only disadvantage is that a fair degree of technical skill and experience is required to master the various nerve block procedures. With increasing experience, however, one will find a few of the various types of nerve blocks very useful and suitable for operations on ambulatory patients.

Digital Nerve Block. The dorsal and the volar digital nerves may be blocked within the soft tissues at the base of the fingers or the toes for operations on the digits Intradermal wheals are raised on each side, at the base of the digits, and the needle is introduced into the deeper tissues through these wheals The anesthetic solution is deposited close to the bone, the location of the anterior and the posterior nerves (Fig. 32) being kept in mind. From 3 to 5 cc of 1 to 2 per cent procaine will produce adequate anesthesia. It must be remembered that with a digital block or any other type of conduction anesthesia, one must wait a short time for the full anesthetic effect. Usually, from 5 to 10 minutes must elapse from the time of injection for complete anesthesia of the digit. Because operations on fingers and toes rarely require long anesthesia, and because blood flow is controlled by the use of a tourniquet, epinephrine is not used in the anesthetic solution for digital blocks.

***Median, Ulnar and Radial Nerve* Block at the Wrist.** Anesthesia for operations on the hand may be obtained by a block of the sensory nerves at the wrist. Perineural infiltration of the nerves, particularly of the radial nerve, is usually performed, since it is almost impossible consistently to contact each nerve directly. In addition, the superficial sensory branches which join the main nerve trunks higher in the forearm must be blocked by a subcutaneous bracelet injection about the wrist.

Lundy and Tuohy, in speaking of block anesthesia at the wrist, state: "The hand may be anesthetized by intradermal or subcutaneous injection and injection through the balance of the tissues to the bone. This bracelet can be accomplished easily, and it is usually done with 0.5 per cent solution (of procaine or Metycaine). If the needle actually touches a nerve trunk, it should be immobilized there and 5 or 10 cc. of a 1 per cent solution should be injected."[30] This type of block may be performed without an accurate knowledge of the anatomy of the region. However, it is undoubtedly wiser to have a fairly good knowledge of the locations of the main nerve trunks and to make an effort to inject the anesthetic solution actually into the nerve trunk or, at least, in close proximity to it, as a more satisfactory anesthesia is ensured thereby.

The median nerve is superficial in the wrist and may be located easily. It lies just to the radial side of the flexor digitorum sublimis muscle and directly beneath and between the tendons of the palmaris longus and the flexor carpi radialis These superficial tendons, which can be seen or palpated easily, serve as the landmarks for the injection of the median nerve. A 2-in. needle, inserted through an intradermal wheal, should be directed between these tendons on a line with the tip of the ulnar styloid. Then the needle is inserted downward at right angles to the skin and slightly toward the radial side of the wrist for a dis-

tance of 0.5 cm. If paresthesias are obtained in the thumb or the index finger, the needle should be immobilized and 5 cc. of 1 per cent procaine or Metycaine injected. We have obtained our best results in nerve block from direct injection into the nerve and are willing to search for the nerve by moving the needle little by little until the characteristic "electric shock" paresthesia is obtained. If paresthesias are not obtained, from 5 to 10 cc. of procaine should be infiltrated after the needle has reached a depth of 0.5

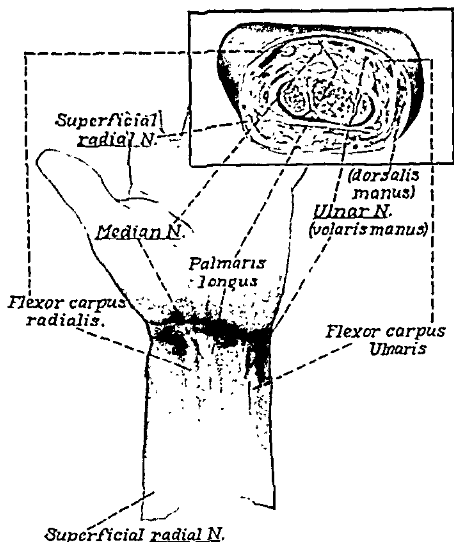


FIG. 33. Wrist block. The median nerve at the wrist lies between and beneath the tendons of the palmaris longus and the flexor carpi radialis; these tendons, therefore, serve as landmarks between which the needle is inserted to block this nerve. The ulnar nerve lies just to the radial side of the flexor carpi ulnaris, which serves as a landmark in the block of this nerve. The radial nerve curves dorsally round the radius in the lower part of the forearm and divides into several superficial branches. These may be blocked by a subcutaneous bracelet infiltration at the wrist.

cm. A part of this solution should be injected toward the radial side of the wrist, as the median nerve may lie directly beneath the flexor carpi radialis at this level (Fig. 33).

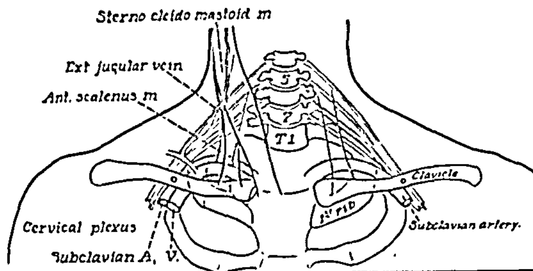
A block of the ulnar nerve at the wrist is performed through an intradermal wheal slightly to the radial side of the flexor carpi ulnaris at the level of the ulnar styloid. The needle is inserted at right angles to the skin, through the deep fascia, for a depth of 0.5 to 1 cm. An effort should be made to obtain paresthesias, as perineural infiltration of the ulnar nerve at this region is often unsuccessful because the solution is injected into the sheath of the flexor carpi ulnaris tendon. The nerve may be reached also from the ulnar side of the forearm, the needle being inserted beneath the tendon, but usually this approach is not as successful. Five cc. of 1 per cent procaine or Metycaine will suffice if the nerve is located accurately.

The radial nerve, which accompanies the radial artery in its course under the brachioradialis muscle in the upper part of the forearm, turns backward over the radius in the lower third of the forearm and divides into several superficial branches. A subcutaneous bracelet infiltration at the wrist suffices to block these branches of the radial nerve. Complete anesthesia of the hand is obtained when this subcutaneous infiltration is combined with a block of the median and the ulnar nerves.

Block of the Ulnar Nerve at the Elbow. A block of the ulnar nerve at the elbow can be performed easily, as the nerve is quite superficial at this point. With the forearm slightly flexed, the nerve may be palpated as a round cord in the medial olecranon groove. It lies in contact with the periosteum under the deep fascia of the arm.

Injection of the ulnar nerve at this point can be accomplished best with the arm in extension. The needle is inserted through an intradermal wheal and directed upward in the groove between the olecranon and the internal condyle of the humerus, in a direction almost parallel to the course of the nerve. Paresthesias of the fourth and the fifth fingers indicate direct contact with the nerve. If paresthesias are not obtained, the solution should be injected beneath the deep fascia, close to the bone. Procaine hydrochloride 1 per cent or Metycaine 1 per cent should be used, in amounts from 5 to 10 cc. Anesthesia of the entire fifth finger and corresponding ulnar surface of the hand to the wrist will be complete, with varying degrees of anesthesia on the ulnar surface of the fourth finger.

Brachial Plexus Block. Anesthesia of the hand, the forearm, the arm and some of the deeper structures about the shoulder may be produced satisfactorily by a block of the brachial plexus. The indications for this type of anesthesia for operations on the upper extremity are limited only by the technical skill of the surgeon. It may be used for the repair of lacerated tendons at the wrist, for the reduction of fractures, for the plastic repair of contractures of the hand, for amputations up to the middle of the humerus, and for any number of other procedures. It is especially useful in the repair of lacerated tendons and the reduction of fractures, for the patient will be able to move individual muscle groups and can be moved about to facilitate fluoroscopic observations and application of dressings. Debilitated patients may be handled with a mini-



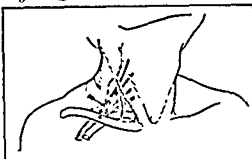


FIG. 31. Brachial plexus block. A skin wheal is made a finger's breadth above the mid point of the clavicle, and a 20-gauge 3-in. needle is introduced downward, inward and backward. The scalenus anticus and the subclavian arteries are palpable landmarks. The plexus lies behind the scalenus and above the artery. As the needle is advanced, the first rib may be met. This lies below the plexus, and the needle tip may be moved forward along it. As soon as paresthesia is obtained in the arm or the hand, the injection is made.

mum of shock. Infection in the supraclavicular region and evidence of disease of the nerve trunks are the only contraindications to the procedure.

Success in blocking the brachial plexus depends largely on an accurate knowledge of the anatomic formation of the plexus and its topographic relationships with the structures in the supraclavicular region. The individual nerves which comprise the brachial plexus arise from the anterior rami of the fifth, the sixth, the seventh and the eighth cervical and the first thoracic nerves, with occasional branches from the fourth cervical and the second thoracic nerves.[10] These anterior roots, after giving off several branches, as they descend under the anterior scalene muscle, converge to form large nerve trunks, which later are assembled into compact bundles as they pass downward and laterally behind the clavicle into the axilla. Just above the clavicle, at its mid-portion, the compact cords of the brachial plexus lie close to the surface of the first rib. The subclavian artery lies immediately internal to the plexus, in the angle formed by the anterior scalene and the first rib. It is generally agreed that the brachial plexus can best be blocked at this point, where the cords pass over the first rib above the clavicle.[49] The supraclavicular injection technic described by Labat[24] is, therefore, the method in common usage.

The patient should be placed on his back, with his head turned toward the opposite side, and the point of the shoulder lowered by keeping the arm to be anesthetized close to the body (Fig. 34). Then the mid-point of the clavicle is selected. This is usually close to the point where the external jugular vein approaches the clavicle. An intradermal wheal is raised one finger's breadth (1 to 2 cm.) above the clavicle. A 2-in. needle, not attached to the syringe, is used so that puncture of a vessel will be obvious immediately. This is inserted through the intradermal wheal and directed downward, backward and inward. The needle passes just to the lateral side of the subclavian artery, which in thin individuals, may be palpated and slightly depressed with the index finger of the surgeon's left hand. The needle may then be guided close to the artery without puncturing it. This landmark is a considerable aid in locating the position of the plexus.

Paresthesias in the arm or the hand may be elicited as the needle is inserted. These occur most frequently about the elbow or in the fingers on the ulnar side of the hand as an "electric shock" sensation. The patient should be instructed to report the location of any paresthesias but must be warned not to move If paresthesias are not obtained, insertion of the needle is continued for a distance of 1 to 3 cm , depending on the habitus of the individual. At this depth, the point of the needle will contact the first rib, unless the direction is entirely wrong. Then the needle should be withdrawn, the direction altered slightly and then reinserted. When definite paresthesias are elicited, the needle is held firmly in that exact location, the syringe attached and 20 cc. of a 2 per cent procaine or 1 per cent Metycaine solution injected. Aspiration always should precede the injection to make certain that the point of the needle is not within a vein.

When it is impossible to obtain paresthesias, Labat[24] recommends the injection of 10 cc. of 2 per cent procaine into the fascia just above the first rib, 5 cc. at the lateral margin of the rib and 5 cc. toward the transverse process of the sixth cervical vertebra. With sufficient skill, however, it is usually possible to elicit paresthesias after one or two attempts. The anesthesia will invariably be more effective if paresthesias are elicited, and it is worth while to spend some time in attempting to obtain them.

Serious complications resulting from attempted brachial plexus block are rare and seldom occur with careful technic. Minor complications may be encountered, but should cause no great concern. Hematoma in the supraclavicular fossa may result from the accidental puncture of a vein. Occasionally, the subclavian artery may be punctured by an inexperienced person; little damage is done if a small-bore needle has been used and if pressure is applied immediately. Another complication may be partial pneumothorax if the needle is inserted too deeply, with resulting dyspnea and pleural pain. Transient phrenic paralysis may also occur, but this will disappear within a few hours. If the solution is injected accidentally into a vein, toxic systemic manifestations may result.

The most serious and annoying complication of brachial plexus block is a residual brachial plexus neuritis. This occurs only if the nerves have been traumatized by the point of the needle. Repeated unsuccessful at-

tempts to determine the location of the first rib and attempts to change the direction of the needle without withdrawing it until the point is near the skin surface undoubtedly account for the majority of complications of this type. In several hundred brachial plexus blocks performed on ambulatory patients, we never have had any complications except the formation of a small hematoma.

Caudal Anesthesia. This method of conduction anesthesia is produced by the injection of an anesthetic solution through the sacral hiatus into the extradural space of the sacral canal. A sensory and motor nerve block of the sacral and the coccygeal nerve roots is produced. The caudal injection may be supplemented by a transsacral block of the sacral nerve roots by injections through the sacral foramina.[28,46] These additional injections are designed to produce a more extensive and certain anesthesia within a shorter period of time. However, transsacral block is technically difficult and time consuming. With the proper performance of caudal block and the proper selection of the anesthetic solution, adequate anesthesia for all purposes may be obtained by caudal block alone.[5,41]

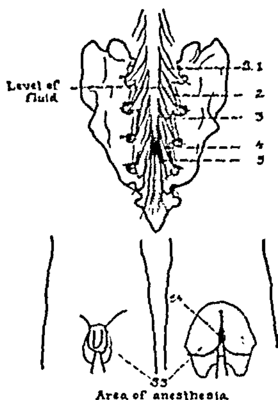


FIG. 35. Caudal anesthesia. The upper figure shows the anesthetic solution deposited in the epidural space up to the level of the second sacral nerve. The two lower figures are anterior and posterior views showing the skin areas which would be anesthetized by blocking the third, the fourth and the fifth sacral nerves.

The sacral canal contains the last 5 sacral nerves and the coccygeal nerves of each side, as well as the terminal filaments of the cord. The third and the fourth sacral nerves innervate the the anorectal region and the external anal sphincter through the inferior hemorrhoidal branch of the internal pudendal nerve. The levator ani receives its nerve supply chiefly from the third sacral nerve but partly also from the second and the fourth sacral nerves. The visceral branches to the bladder, the prostate and the urethra in the male and to the bladder, the urethra and the vagina in the female are derived principally from the second, the third and the fourth sacral nerves.[10] Block of these nerve roots by the injection of an anesthetic solution into the sacral canal produces anesthesia of the structures of the perineum and the external genitalia which is adequate for perineal surgery of the genito-urinary tract, for anorectal surgery and for minor gynecologic procedures (Fig. 35).

Metycaine 1 to 2 per cent should be the local anesthetic agent of choice for

a caudal block.[43,50] This agent produces a more rapid and longer-lasting anesthesia than procaine, with fewer failures. Reactions are few if no more than 20 cc. of 2 per cent Metycaine or 40 cc. of 1 per cent Metycaine is used.

The sacral hiatus is first located,

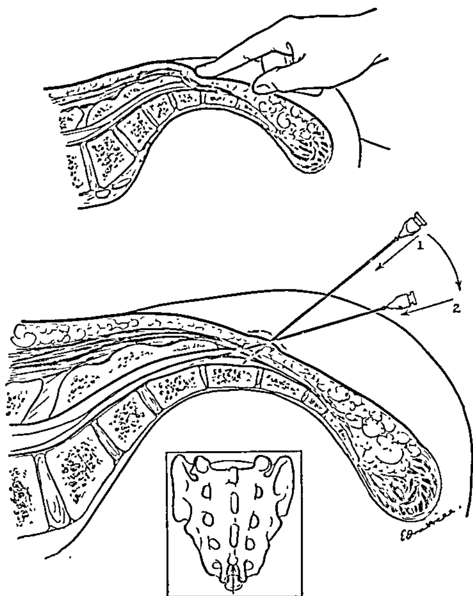


FIG. 36. Technic of caudal anesthesia. With the patient in the lateral or the prone position, the sacral hiatus is located by palpation with the index finger at the triangular depression lying between the sacral cornua and below the level of the last spinous process An intradermal wheal is then raised over the hiatus, and the subcutaneous tissue and the sacrococcygeal ligaments are infiltrated. A large-caliber spinal needle is inserted through the skin wheal and at right angles to the skin until it penetrates the ligaments and contacts the bone beneath (Position 1). The hilt of the needle is then depressed as the point is advanced into the sacral canal (Position 2). The inset shows the sacrum with an arrow in the sacral canal.

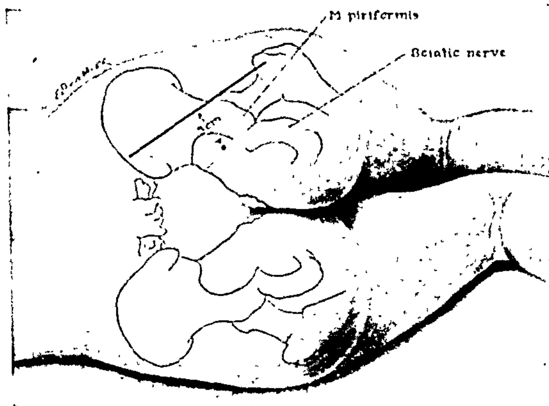


FIG. 37. Sciatic nerve block. With the patient in Sims's position, the side to be injected uppermost, an imaginary line is drawn between the posterior superior iliac spine and the superior border of the greater trochanter. This line is bisected by a perpendicular line drawn upon its mid point. Three cm. down on this perpendicular line an intradermal wheal is raised. Through this wheal a long needle is inserted at right angles to the skin to deposit the anesthetic solution for the block.

with the patient in the lateral or the prone position. Ordinarily, the hiatus may be palpated easily as a triangular depression lying between, and slightly below, the level of the sacral cornua. In an obese individual, the sacral hiatus may be located by constructing an imaginary equilateral triangle, with a line drawn between the posterior superior spines as its base. The apex of the triangle always will be at the sacral hiatus.[41]

An intradermal wheal is raised over the hiatus, and the subcutaneous tissues and the sacrococcygeal ligament are infiltrated with 2 or 3 cc. of Metycaine solution. During this preliminary infiltration, it is advisable to mark the location of the hiatus by keeping the left index finger in place just above the site of proposed injection. Then a large-caliber spinal needle is inserted through the skin wheal, at right angles to the skin, until it penetrates the ligament and contacts the bone beneath. The hilt of the needle is depressed as the point is advanced into the sacral canal. Aspiration always should be performed prior to the injection of the anesthetic solution in order to avoid an intravenous or intradural injection (Fig. 36).

The most common technical error in performing a caudal block is to miss

the sacral hiatus and insert the needle into the soft tissues along the posterior surface of the sacrum. If this has occurred, palpable bulging of the tissues may be detected when the anesthetic solution is injected. As a rule, the injection into the caudal canal can be made with very little pressure on the plunger of the syringe. If the injection is difficult, it is quite likely that the needle is not in the canal.

The caudal canal is filled with highly vascular areolar tissue, so that one quite frequently punctures a vein and aspirates blood. If this occurs, the depth to which the needle has been inserted may be altered until blood can no longer be aspirated; then the injection is continued.

Less satisfactory anesthesia will be obtained if the position of the needle in the caudal canal is poor. It should be directly in the mid-line and should be inserted until its tip is approximately on a level with the third sacral foramen. The anesthesia will also be unsatisfactory if the surgeon does not wait a sufficient length of time after the injection before starting any operative procedure. With Metycaine, complete anesthesia may be obtained in 10 minutes. If procaine is used, one should wait 15 to 20 minutes for the full anesthetic effect.

Sciatic Nerve Block. The sciatic nerve may be blocked easily near its exit from the sciatic foramen. The resulting anesthesia may be used for the reduction of fractures about the ankle or for operations on the posterior aspect of the thigh. However, sciatic block is chiefly employed for the diagnostic and the therapeutic management of sciatic neuralgia.

A satisfactory approach to the sciatic nerve is obtained with the patient in Sims's position (Fig. 37). An imaginary line is drawn between the posterior superior iliac spine and the superior border of the greater trochanter. This line is bisected, and an intradermal wheal is raised 3 cm. beneath its mid-portion. Then a 4-in. needle is introduced through this wheal and inserted at right angles to the skin for a distance of 6 to 8 cm., depending on the habitus of the patient. The point of the needle should strike bone at this depth. If no paresthesias are obtained, the needle should be withdrawn and reinserted. It is usually quite easy to elicit paresthesias, as the sciatic nerve is large at this point. Twenty cc. of 1 per cent procaine or Metycaine will suffice for the production of anesthesia.

Haggart[20] has suggested another method for injecting the sciatic nerve, which also is performed easily (Fig. 38). With the patient in the prone position, the hip joints are flexed approximately 20°. The buttock on the side to be injected is exposed, and the point of the insertion of the needle is determined by the intersection of a line projected from 3 in. (in the male) to 3½ in. (in the female) directly lateral from and at the level of the apex of the intergluteal fold and an imaginary perpendicular line erected from the ischial tuberosity. This point is marked on the skin by a small dot of gentian violet. The point of injection is checked further by drawing another imaginary line from the mid-lateral aspect of the greater trochanter to the spinous processes of the fifth lumbar vertebra. This line indicates the extreme lateral margin of the injection field. In the average pelvis, this line will intersect the two lines already mentioned at the same point. The skin is anesthetized over the area identified by the mark, and a 20-gauge 6-

in. needle is passed in an anteromedial direction from this point at an angle of 45° with the skin surface. Little or no discomfort is experienced until the fascia underlying the mass of the gluteus maximus is encountered. A further injection of procaine may be necessary. If the needle is in the correct position as it progresses inward, the patient will experience a transitory lightninglike pain extending down the posterior mid-line of the lower extremity to correspond with the general course of the sciatic nerve. With the needle in this position, an injection may be made into the sciatic nerve sheath or into the perineural area. This type of injection has been recommended by Haggart[20] in the treatment of some forms of sciatic pain of unknown or undetermined origin.

Internal and External Popliteal Block. The internal popliteal (tibial) and external popliteal (common pero-

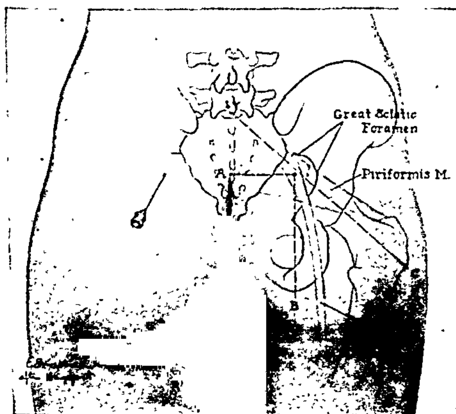
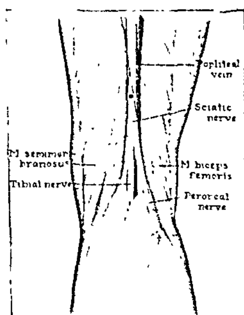


Fig. 38. Sciatic nerve block, Haggart's method. With the patient in the prone position and the hips flexed 20°, a line is projected laterally 3 to 3½ in. from the apex of the intergluteal folds. This line is intersected by an imaginary perpendicular line from the ischial tuberosity. The point of injection is further checked by a line drawn from the spinous process of the fifth lumbar vertebra to the medial lateral aspect of the greater trochanter. At the site of intersection of these lines an intradermal wheal is raised The needle for injecting the anesthetic solution for the block is advanced through this wheal in an anteromedial direction at an angle of 45° with the skin surface.

neal) nerves may be blocked as they enter the popliteal space. This block, together with a subcutaneous zone of infiltration just above the operative site, affords complete anesthesia of the lower leg and the foot. With the patient in the prone position, the angle formed by the biceps and the semimembranosus muscles can be identified by having the patient flex the leg at the knee against resistance. An intradermal wheal is raised at this point, about 7 cm. above the bend of the knee joint. Then a 3-in. needle is introduced, at right angles to the skin, until the point of the needle is felt to penetrate the deep fascia. The needle is inserted further for a distance of 1 to 1.5 cm. Strenuous efforts to obtain paresthesias should not be made, for the popliteal vein lying just mesial to and below the nerves may be in-



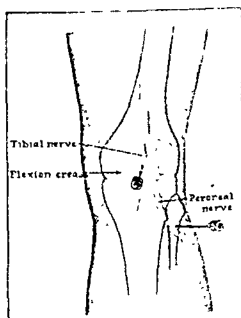


Fig 39 (*Left*) Popliteal nerve block. The sciatic nerve or its branches may be blocked as they enter the popliteal space. With the patient in the prone position, the angle formed by the semimembranosus and the biceps femoris muscles may be identified by flexion of the knee against resistance. An intradermal wheal is raised at this point, and through this the needle is introduced at right angles to deposit the solution for the block. Undue probing with the needle should be avoided because of the proximity of the nerves in this area to the popliteal vein.

Fig. 40 (*Right*) Block of the tibial and the common peroneal nerves With the patient in the prone position, an intradermal wheal is raised just lateral to the mid-line in the flexion crease. The needle is inserted through this wheal, and some of the anesthetic solution is deposited in the subcutaneous tissues to block the superficial cutaneous nerves The needle is then advanced through the popliteal fascia, and solution is deposited to block the tibial nerve. The common peroneal nerve curves downward round the head and the neck of the fibula; to block it, therefore, the needle is inserted in the lateral side of the leg at the neck of the fibula just below the prominence of the head.

jured. Infiltration of the loose areolar tissue in this region will suffice if paresthesias are not elicited. Twenty cc. of 1 per cent procaine or Metycaine should be used (Figs. 39 and 41A).

Block of the Tibial and the Common Peroneal Nerves at the Knee for Anesthesia of the Foot and the Lower Leg. This type of anesthesia[22] may be employed for operations or for reduction of fractures in the lower leg, and may be somewhat easier and less dangerous in its induction than is the popliteal-nerve block (Figs. 40, 41B and C). The patient is placed on his abdomen, and the knee is flexed to locate the flexion crease. After preparation of the skin, a needle is inserted

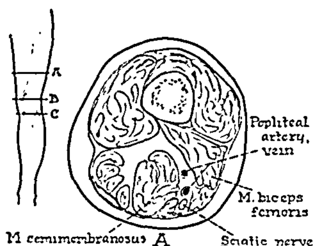
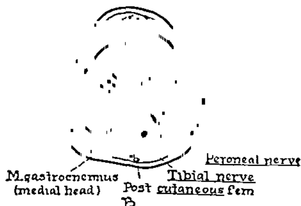
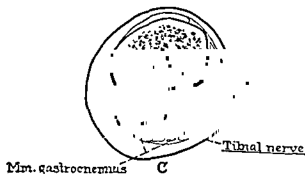


Fig. 41.

(A) Cross section of the thigh at the level of the popliteal block (Fig. 39). The nerve or its branches are very superficial at this level, and their proximity to the popliteal vessels is indicated.

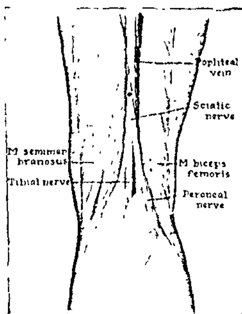


(B) Cross section of the knee at the level of the flexion crease to show the relation of the tibial nerve to the vessels. The posterior cutaneous femoral nerve is superficial and must be blocked before the needle is advanced more deeply to block the tibial nerve, which at this level is also relatively superficial.



(C) Cross section of the leg at the level of the neck of the fibula to show the location of the peroneal nerve.

neal) nerves may be blocked as they enter the popliteal space. This block, together with a subcutaneous zone of infiltration just above the operative site, affords complete anesthesia of the lower leg and the foot. With the patient in the prone position, the angle formed by the biceps and the semimembranosus muscles can be identified by having the patient flex the leg at the knee against resistance. An intradermal wheal is raised at this point, about 7 cm. above the bend of the knee joint. Then a 3-in. needle is introduced, at right angles to the skin, until the point of the needle is felt to penetrate the deep fascia. The needle is inserted further for a distance of 1 to 1.5 cm. Strenuous efforts to obtain paresthesias should not be made, for the popliteal vein lying just mesial to and below the nerves may be in-



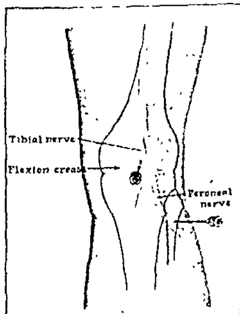


FIG 39 (*Left*). Popliteal nerve block The sciatic nerve or its branches may be blocked as they enter the popliteal space. With the patient in the prone position, the angle formed by the semimembranosus and the biceps femoris muscles may be identified by flexion of the knee against resistance An intradermal wheal is raised at this point, and through this the needle is introduced at right angles to deposit the solution for the block. Undue probing with the needle should be avoided because of the proximity of the nerves in this area to the popliteal vein.

FIG. 40 (*Right*). Block of the tibial and the common peroneal nerves With the patient in the prone position, an intradermal wheal is raised just lateral to the mid-line in the flexion crease The needle is inserted through this wheal, and some of the anesthetic solution is deposited in the subcutaneous tissues to block the superficial cutaneous nerves. The needle is then advanced

side of the leg at the neck of the fibula just below the prominence of the head.

tion of the surgical results which may be obtained. For instance, patients with peripheral vascular disease should receive repeated lumbar sympathetic blocks before surgical sympathectomy is considered. A poor response to sympathetic blocks may contraindicate surgical therapy. The pain of trigeminal neuralgia always should be treated initially by gasserian ganglion block or injection of the involved nerve root. Such management permits the surgeon to evaluate the results which may be expected of surgical nerve section and also allows the patient to become accustomed to the resultant facial anesthesia. Splanchnic block[11,32] and high continuous caudal anesthesia[42] have been used preoperatively in hypertensive patents being evaluated for thoracolumbar sympathectomy. Although the surgical results have not correlated well with the results obtained by procaine block,[33] the relative simplicity of the injection technic should make this procedure part of the preoperative evaluation of the hypertensive patient.

Therapeutic Blocks

The use of regional anesthesia as a therapeutic tool for the control of pain has received the greatest amount of attention. The results obtained by this treatment of pain have been most confusing and controversial. This is no doubt due to the controversial and confusing nature of pain itself Pain therapy has been the responsibility of every medical specialty. Therefore, diagnosis, methods of treatment and results have not been uniform or valid. Analgesic block is of value in pain therapy, but its scope and extent of usefulness are vague. Only time will determine whether or not the benefits claimed for regional anesthesia are justified. Therapeutic analgesic block is employed to produce (1) relief of pain, (2) interruption of noxious reflexes (reflex sympathetic dystrophies), (3) vasodilatation. Analgesia may be obtained by the injection of somatic nerves or sympathetic nerves, or by direct infiltration of a local anesthetic solution into a painful area. The use of sympathetic nerve block deserves special mention because of its increasing field of applicability to various pain syndromes (causalgias, vascular disease and visceral pain). The sympathetic chain may be interrupted chemically in the cervical (stellate ganglion block), the thoracic or the lumbar area. Stellate ganglion block has been advocated for a diversity of conditions such as cerebrovascular disease,[52] vascular disease of the upper extremity (occlusive diseases of arteries, injury to arteries),[17] pain following pulmonary embolism, arthritis, bursitis, causalgia (major and minor) and others too numerous to mention. The best results have been obtained in the treatment of vascular diseases and reflex sympathetic dystrophies (causalgia). The stellate ganglion formed by the fusion of the inferior cervical and the first thoracic sympathetic ganglia is situated slightly lateral to the body of the seventh cervical vertebra. It is limited inferiorly by the posterior aspect of the pleura, medially by a portion of the vertebral column, laterally by the scalenus-muscle mass, anteriorly by the vertebral and the subclavian arteries, and posteriorly by the neck of the first rib. Block of the stellate ganglion is performed by inserting a needle through a skin wheal located 2.5 cm. lateral to the jugular notch and 3.5 cm. above the clavicle. This site is located over the transverse process of the seventh cervical vertebra

into the skin of the flexion crease of the popliteal space at a point just a little to the outside or lateral to the center of the leg. The tibial nerve lies not exactly in the mid-line but at a very slight distance lateral to the mid-position. Five cc. of a 2 per cent procaine solution is injected just beneath the skin at this site. The needle point at this time lies just beneath the skin and anesthetizes the median cutaneous branch of the tibial, which often comes off higher than the other cutaneous and muscular branches and comes down the leg more superficially but parallel to the tibial and the posterior tibial nerves. This injection of the subcutaneous tissue will block these fibers.

Then the needle is inserted deeper without changing its position or direction. Just after piercing the popliteal fascia, the tip of the needle will be on or immediately adjacent to the tibial nerves. Fifteen cc. of a 2 per cent procaine or 1 per cent Metycaine solution is injected. It is not necessary to try to place the procaine in the nerve trunk; if it merely surrounds it, it will be absorbed sufficiently to produce anesthesia, although a quicker and better anesthesia will be produced by a direct injection into the nerve trunk.

The common peroneal nerve has a constant and unvarying location as it curves downward round the head and the neck of the fibula. This area is located easily. The needle is inserted in the lateral or the posterolateral aspect of the fibula just below the prominence of the head. Most often, as the needle is inserted, the patient will experience a sharp lightninglike shock down the lateral surface of the leg. Ten cc. of 2 per cent procaine or 1 per cent Metycaine solution is injected at this site. The anesthesia usually begins in about 10 or 15 minutes, with relaxation of most of the muscles of the lower leg and the foot.

Diagnostic, Prognostic and Therapeutic Uses of Local Anesthesia

In recent years, regional anesthesia has been employed in the diagnosis, the prognosis and the therapy of various pathologic entities.[43] This general aspect of regional anesthesia received much attention during and following World War II. Its usefulness and efficacy are being investigated thoroughly and evaluated.

Diagnostic Blocks

Regional anesthesia used in peripheral vascular disease may reflect the degree of vasospasm present in contrast with actual organic occlusion of the vessels.[17] It may also help to differentiate between functional vasospastic disorders and organic-vessel changes.

Diagnostic blocks may be employed to differentiate between somatic and visceral pain. Relief of abdominal-wall pain by somatic intercostal nerve block (which does not interrupt visceral afferent fibers) suggests that the pain is not of visceral origin. However, it must be stressed that injection of the site of reference of visceral pain may relieve the symptoms of visceral disease.[54]

Regional block may be useful in differentiating between true pain and malingering, although great care must be exercised before a diagnosis of malingering is made.

Prognostic Blocks

The reversible interruption of nerve impulses made possible by local anesthetics permits a preoperative evalua-

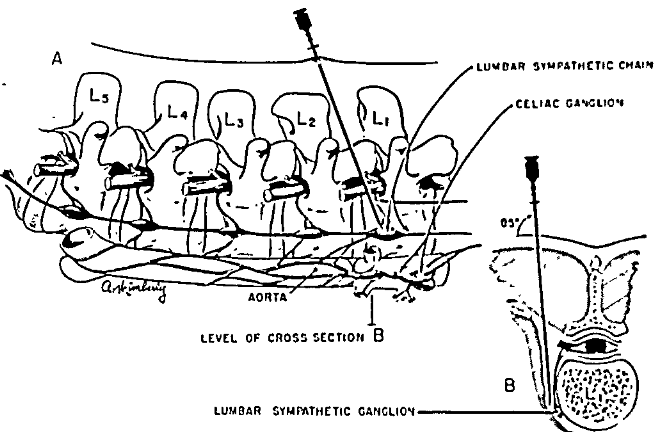


FIG. 13. Paravertebral lumbar sympathetic block. (A) The lumbar sympathetic ganglia, situated on the anterolateral aspect of the bodies of the lumbar vertebrae, may be blocked by inserting a 4-in. No. 22-gauge needle through a skin wheal raised 5 cm. lateral to the superior tip of the spinous processes. The needle is advanced perpendicularly through the skin until the transverse process is contacted, then it is withdrawn and redirected medially and cephalad. The tip of the needle should just slide over the body of the vertebra. (B) Cross section through the body of the first lumbar vertebra, illustrating the correct position of the needle.

and may be located roughly by measuring 2 fingers lateral to the jugular notch and 2 fingers above the clavicle (Fig 12). With the patient in the supine position and head turned toward the opposite direction, the sternocleidomastoid muscle and the carotid sheath are retracted laterally. A 2-in. 22-gauge needle is inserted perpendicularly through the skin wheal and slowly advanced posteriorly until it impinges on the transverse process of the seventh cervical vertebra. From 10 to 15 cc. of 1 per cent procaine with or without epinephrine is injected. Anesthesia appears in 2 to 10 minutes and is evident by the development of a Horner syndrome on the injected side (ptosis, myosis, endophthalmus, increased arm and face temperature on the injected side). Complications such as pneumothorax (1% of cases), spinal anesthesia (rare), intravascular injection (rare), hoarseness (recurrent nerve block) and asthmatic attacks (rare) may occur.

Paravertebral Lumbar Sympathetic Ganglion Block

The lumbar sympathetic ganglia

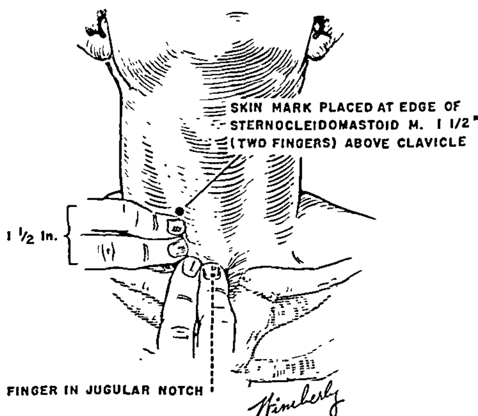


Fig. 42. Stellate ganglion block. The stellate ganglion may be blocked (anterior approach) by raising a wheal 2.5 cm. lateral to the jugular notch and 3.5 cm. above the clavicle A needle inserted perpendicular to the skin is advanced until the transverse process of the seventh cervical vertebra is contacted. Injection of 10 to 15 cc. of 1 per cent procaine is made at this site.

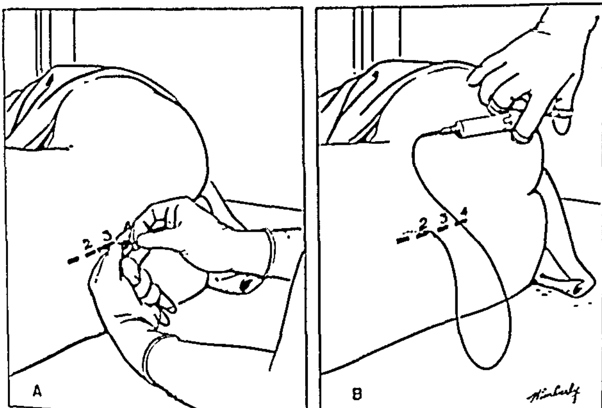


Fig. 41. Continuous sympathetic block by epidural injection. Insertion of a small ureteral catheter (F 3.5) in the epidural space permits a continuous bilateral block of the sympathetic chain. (A) A 17-gauge spinal needle is inserted into the epidural space at any desired level, and the small catheter is threaded through the needle for 5 to 7 cm (B) The needle is withdrawn, leaving the catheter in place. Intermittent injection of 20 cc. of 1 per cent procaine every 4 hours produces continuous bilateral sympathetic block.

needle; (2) choosing a site of injection close to those nerves which are to be blocked (thoracic or lumbar sympathetics); (3) injecting a trial dose of local anesthetic to detect subarachnoid injection; (4) inserting of 3.5 F ureteral catheter or plastic tubing of similar size through the needle. The catheter should be threaded upward within the space for 5 to 7 cm. before the needle is withdrawn. From 20 to 25 cc. of ½ or 1 per cent procaine injected every 4 hours will produce continuous sympathetic block. Catheters have been left in place for from 2 to 3 days without ill effect. This technic produces a bilateral diffuse sympathetic nerve block.

Intraligamentary injections of procaine have been used advantageously in the treatment of acute sprains[26,51,53] and of articular fractures without displacement and not requiring exact reduction. Leriche and Arnulf[26] recommend the injection to 10 to 20 cc. of 1 per cent procaine hydrochloride in the region of the traumatized ligament. The point selected for the injection is the spot of maximum tenderness, but care is also taken to inject

situated on the anterolateral aspect of the lumbar vertebrae bilaterally are blocked therapeutically in vasospastic disorders of the lower extremities and reflex sympathetic dystrophies (causalgia),[12] phantom limb pain.[27] With the patient in the prone position and a pillow under the abdomen, the lumbar spinous processes are palpated (Fig. 43). Skin wheals are raised 2½ fingerbreadths (5 cm.) lateral to the spinous processes. A 22-gauge 10-cm. needle is inserted through the wheals perpendicular to the skin to a depth of 3 to 5 cm until the tip of the needle impinges upon the transverse process. The needle is directed slightly cephalad and inserted another 4 to 5 cm. until the tip can be felt just sliding off the anteriolateral aspect of the body of the vertebra into the retroperitoneal space. Ten cc. of 1 per cent procaine is injected at each site. Complications are rare.

On occasion, continuous lumbar or thoracic sympathetic block is indicated. Such a block may greatly benefit a patient with arterial embolism of the lower extremity, thrombophlebitis or traumatic injury of an extremity vessel which has been repaired surgically. Continuous thoracic sympathetic block has been advocated for the treatment of various visceral pain syndromes (pancreatitis,[14,16] postcholecystectomy syndrome[14]). Continuous sympathetic block may be produced by inserting a small ureteral catheter (3.5 F) or plastic tubing of similar caliber in the vicinity of the sympathetic ganglia which are to be blocked. This is done easily by performing the initial block with a No. 17 spinal needle and, when the needle is localized correctly, by threading a flexible tube through the needle. The tubing is left *in situ* until the needle is removed over the tubing. The injection of 15 to 20 cc. procaine (1%) every 4 hours will produce continuous block. A more effective method of instituting bilateral widespread continuous sympathetic block is by the insertion of a small ureteral catheter (3.5 F) or plastic tubing in the epidural space (Fig. 44) at the appropriate level of the sympathetic chain.

Widespread bilateral sympathetic block is of particular value in various visceral diseases because of the diffuse anatomic innervation of these organs. The deposition of a local anesthetic solution in the epidural space will block efferent preganglionic sympathetic fibers as they leave the spinal cord via the anterior (motor) nerve roots and traverse the epidural space. The epidural, or peridural, space is situated between periosteum of the spinal vertebrae and the dural sheath. It is continuous with caudal canal inferiorly and terminates superiorly at the foramen magnum. Epidural puncture is performed in the same manner as subarachnoid puncture. The essential difference is that as the ligamentum flavum is pierced, and resistance is encountered, the needle is advanced very cautiously so that the bevel just clears this structure and does not enter the subarachnoid space. A negative pressure is usually present in the epidural space and, as this area is entered, a drop of fluid placed on the opening in the hub of the needle will be sucked inward (hanging drop test). Other methods of verifying the position of the needle in the epidural space is by the inability to aspirate spinal fluid and the relative ease of injection.

Continuous sympathetic block via the epidural space entails (1) epidural puncture with a No. 17 spinal tap

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the ligament itself. Immediate activity is permitted and can be performed painlessly if the injection has been adequate. Ordinarily, a simple injection is sufficient, but, if not, subsequent infiltrations are made during the next few days. Ware[33] partially or completely immobilizes some cases after the procaine injection.

Numerous reports[4,25,38] have appeared describing the use of local anesthesia in the treatment of contusions, sprains and other minor injuries occurring in the military service Procaine hydrochloride (2%) was injected at the most painful point. Occasionally, some supportive adhesive strapping or elastic bandage was applied, but active function of the part was encouraged.

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4.

Preparation for and Conduct of Operation on Ambulatory Patients

PREPARATION OF THE PATIENT FOR OPERATION

Ambulatory patients who present themselves to the surgeon with lesions requiring operation usually have not been prepared for operation in the ordinary sense. Very frequently, the patient does not wish or expect to be treated by operation. In such cases, it is wise to explain the reasons for operative therapy without urging the patient to submit to operation. Peculiarly enough, it seems that when operation is urged upon a reluctant patient the results are often unfortunate. The surgeon should not undertake any form of operative procedure on a minor without obtaining the consent of the responsible parent or guardian. Many times a friend or a relative of the child will give consent for operation; such acceptance may lead the surgeon into serious legal difficulties. Written consent for operation on a minor or an adult should be obtained before the operative procedure is carried out.

When operation is refused or is delayed for any reason, it is best to make a careful note on the history of the patient, setting forth all the facts and the circumstances as they occur. The signature of a nurse or an associate should be recorded also in the event that complications develop later.

In preparing the patient, sufficient clothes should be removed to permit adequate exposure of the field of operation, and special care should be taken to prevent soiling the patient's garments. The use of a hospital gown is a convenient substitute for other clothes in many cases. As a rule, no preoperative medication is used.

In dealing with children, many difficult situations may arise. The easiest method of handling a child capable of reasoning is to explain frankly and in simple terms the operative procedure which is proposed. If it is possible to gain the child's confidence in a short conversation, no difficulty need be experienced. In many cases, a fond parent is more upset about the operation than is the child, and this anxiety frequently passes from parent to child. It is wise in such instances to obtain permission for operation from the parent and then excuse the parent from any knowledge of subsequent procedures. A child alone may often be persuaded or instructed when this would be impossible in the presence of the parents. One very excellent method of allaying the anxiety of a

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being used. After a 5 minute scrub the excess suds are washed off, the hands and the arms are dried with a sterile towel, and a sterile gown and gloves are put on.

APPLICATION OF WOUND DRAPES

A sterile drape is so placed over the field of operation that the opening in it will give good exposure of the operative site. If the opening is too large and exposes a considerable area of hair or skin surface which cannot be shaved, a smaller opening may be provided with sterile gauze by spreading the mesh with the finger to make a hole of the required size. This can then be placed immediately over the field of operation (Fig. 16).

ANESTHESIA

The surgeon must select the anesthetic, first, with a view to the operation which he proposes to perform and, second, with consideration of the patient. Most operations can be performed under local anesthesia.

However, in many infected lesions in both children and adults who are so apprehensive that local anesthesia cannot be used, divinyl ether (Vinethene) has been employed. When local anesthesia is used, the anesthetic is injected after the field is prepared and the drapes are applied, except in the case of traumatic wounds, the procedure for which is described on page 158. When general anesthesia is used, the field is prepared and draped before the anesthetic is started. The patient is then asked to count or to hold one arm in the air; when the counting stops or the arm falls, the operation is begun. As a rule, relaxation is not necessary for operations performed on ambulatory patients. When general anesthesia is to be used,



Fig. 45. Unsterile assistant outside the field of operation is aiding the surgeon by retraction. The assistant is reaching beneath the sterile drape and grasping the end of the *retractor*.

child is to occupy his mind with thoughts other than the operation. It is often possible to carry on an animated and an interesting conversation throughout the entire procedure, but once the child's thoughts return to the operation he may again become anxious and fearful. Many children cannot be reasoned with at all; with them it is a useless waste of time to continue such methods. A firm manner must be adopted and the procedure carried through by the use of restraint if necessary.

The patient should be placed on the table by the surgeon or his nurse in a position in which the lesion is easily accessible. Descriptions of the positions found to be most convenient for various operations will be given in the section on regional therapy.

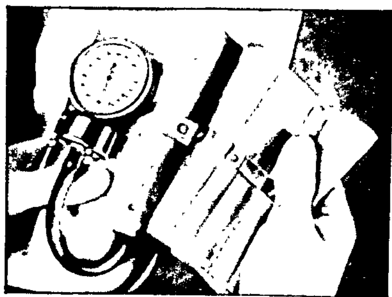
PREPARATION OF THE FIELD OF OPERATION

When the operation is to be performed upon hairy parts, the field must be shaved For operations on the head, a suitable area of hair should be cut away with the scissors and the remaining ends of hair removed with a razor. On the scalp, it is preferable to precede the shave with a soap lather, but in most other hairy parts a dry shave is better The short curly hair of the pubic region or of the legs and the arms is removed more easily by brushing or by picking up the loose hairs with a piece of adhesive plaster when the part is dry than by attempting to wipe the hair away as is necessary when the shave has been preceded by a soap lather. If a sharp razor is used, there is little difference in discomfort between a wet and a dry shave. The preparation of the field of operation may be very simple or very complicated. When the part is grossly dirty, it should be washed with green soap and water and followed by clear water. If the part is soiled by grease, a benzene scrub should precede the soapy wash. The skin preparation is completed by at least two washings with 70 per cent alcohol. Experience in operating upon a large number of minor surgical lesions has shown that this method of skin preparation is as effective as is the application of any of the more highly colored and more expensive antiseptics. When the part to be reached by the operation lies at some distance beneath the skin, and especially if such an operation is to be performed with local infiltration anesthesia, it is wise to mark the proposed line of incision and the site of the lesion by the application of some colored solution on the skin. Scratches with the blade of the knife often accomplish the same purpose, but the skin cannot be scratched without pain until after the injection of the anesthetic, which frequently obscures the outline of the lesion.

PREPARATION OF THE OPERATIVE PERSONNEL

For minor operations performed on ambulatory patients the ideal staff consists of the surgeon, an assistant, an anesthetist and a nurse. Very frequently such a staff is not available; as a matter of fact, many operations may be performed by the surgeon with the aid of one other person, usually a nurse, who can hold retractors and generally assist the surgeon outside the sterile field (Fig 45). The same care is necessary in preparing for a minor operation as for a major one. The cap and the mask are put on, and the hands and the arms are scrubbed, one of the soapy antiseptic preparations, Septisol or pHisoHex,

Fig. 47. Lock on blood pressure cuff and sphygmomanometer. It may be used conveniently as a tourniquet



make the incised tissues separate more easily and will compress the vessels which have been cut. As soon as the skin and the subcutaneous tissues have been incised, small rake retractors or Allis forceps may be applied to the lips of the wound. Tension is thus maintained, and often it is sufficient to prevent any very marked bleeding. In operations for subcutaneous cysts and tumors, this method of controlling bleeding is usually all that is necessary. Its effectiveness may be easily noted if one observes the bleeding which almost immediately takes place when the tension is relieved. Tissue tension not only provides a practically bloodless wound but also permits more accurate and rapid dissection. Often, in the removal of a subcutaneous lipoma, the tumor may be delivered without any dissection except the incision with the scalpel and the tension on the wound edges provided by rake retractors.

Third, hemostasis can be maintained by the use of tourniquets, which can be used to advantage only in operations upon the extremities. The cuff of a sphygmomanometer is placed carefully on the arm above the elbow or on the leg at the knee. After the part is elevated to permit the drainage of venous blood, the cuff is then rapidly inflated to a pressure of at least 200 mm. of mercury. The small Tycos type of spring manometer is adequate for this and is less cumbersome than the mercury manometer. The lock-on type of cuff is more convenient than the older wrap-around cuff (Fig. 47). If the tourniquet has been well applied, the part will be completely bloodless and the operation may proceed with almost no sponging. The cuff may be permitted to remain inflated for from 30 to 40 minutes without danger, and, if necessary, in operations which take longer, the pressure may be released for a short time and reapplied. In operations upon the digits, a convenient tourniquet is a piece of rubber tubing; this is placed to encircle the base of the finger or the toe and is held on tension by means of a hemostat. The tourniquet is especially valuable in all operations on the extremities,

a restraining strap should be placed over the patient above the knees.

CONDUCT OF THE OPERATION

In operations performed on ambulatory patients, the operative field and the lesions are relatively small; hence, if rapid and accurate dissection is to be done, a clean dry field is necessary. There are three methods by which the wound may be kept dry:

First, in operations performed under local anesthesia, epinephrine hydrochloride may be added to the anesthetic solution in amounts of 6 to 8 minims to the ounce. This prolongs the duration of the anesthesia, and in many cases it produces a practically bloodless field.

Second, temporary hemostasis can be produced by tissue tension and pressure. While the incision is being made, pressure on each side of the proposed wound by the assistant will

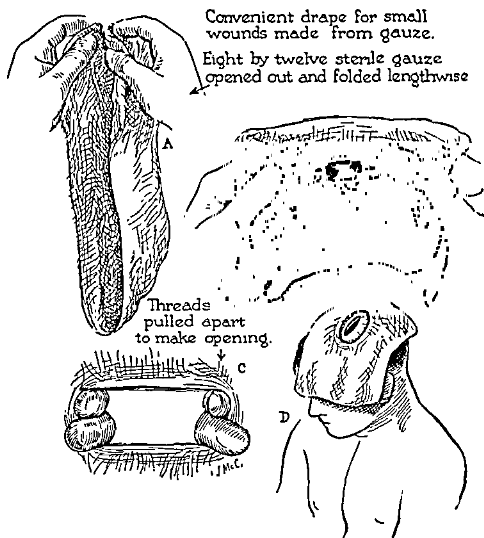


Fig. 46. Method of making drape from gauze for small wounds.

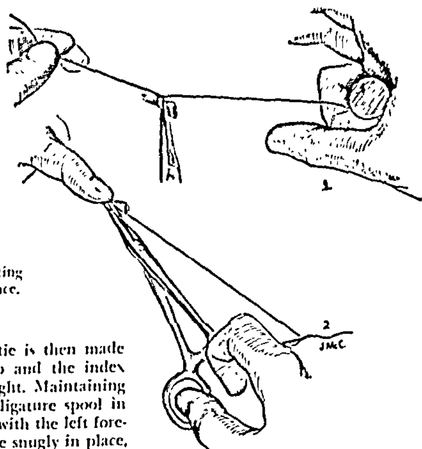


FIG. 49. Method of ligating vessels without assistance.

hand, and a finger tie is then made with the left thumb and the index finger and pulled tight. Maintaining the tension on the ligature spool in the right palm, and with the left forefinger holding the tie snugly in place, the hemostat is freed with the right thumb and the index finger. A second tie is then made in the same manner. (See Figs. 48 and 49.)

WOUND CLOSURE

Clean Wounds. Primary union may be obtained in approximately 98 per cent of the clean wounds in ambulatory cases if special attention is given to the care of tissue and to accurate and careful closure of the wound. The essential points which make for perfect wounds are (1) the obliteration of dead space in the wound; (2) the avoidance of foreign bodies in the wound; (3) accurate skin apposition; and (4) the use of pressure bandages and immobilization dressings. If dead space can be avoided, serum and blood collections are prevented and the chances of primary healing are excellent. In deep wounds, obliteration of dead space is best accomplished by the insertion of several interrupted sutures of No. 000 catgut, fine silk or cotton. These sutures should include the lateral walls of a wound and the tissue at its base, and they should be tied snugly enough to bring these tissues together without undue compression. It is often wise to insert all the sutures before any of them are tied, because, as the wound edges are approximated with the tying of the sutures, it becomes more difficult to catch the base of the wound as the subsequent sutures are inserted (Fig. 50).

The foreign bodies most often left in the wound are large pieces of strangulated tissue and large knots or ends of catgut. Round these areas there is

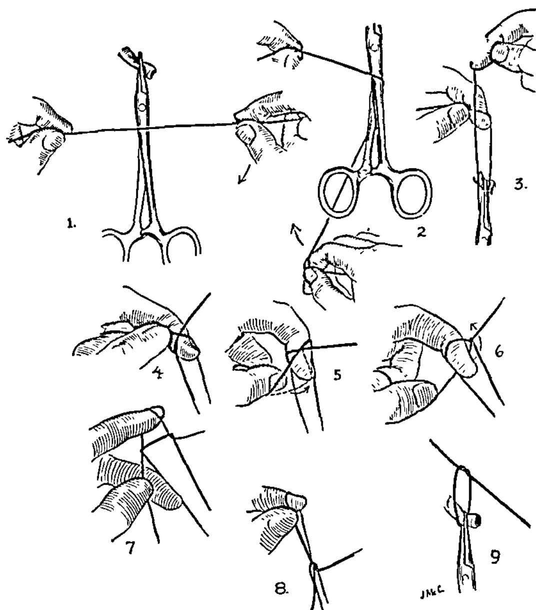


FIG 48. Method of ligating vessels without assistance.

but it is imperative in operations for the removal of foreign bodies, for the suture of tendons and for incision and drainage of infected distal closed spaces and tendon sheaths.

In operating without an assistant or when the assistant is unsterile and holds the retractors outside the sterile field, it is often necessary for the surgeon to ligate vessels alone. The following technic permits safe ligation and removal of the hemostat without dislodging the knot. The ligature, which is usually of silk or cotton wound on a glass or a rubber-tube spool, is held in the right palm. The free end of the ligature is grasped between *the left thumb and the index* finger. The ligature is carried underneath the hemostat with the right

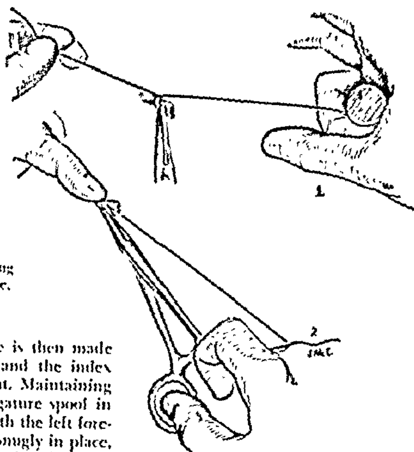


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always an inflammatory reaction, and in such areas of lowered resistance bacteria may thrive. It is important, therefore, to ligate only the tissue including the bleeding vessel, and to cut the ligature material close to the knot. Fine catgut, cotton or silk may be used as ligatures.

Accurate apposition of the skin edges is best obtained by the use of interrupted vertical mattress sutures. Interruption of the sutures permits escape of serum and blood from the wound and so prevents wound collections. The mattress type of suture is useful further in obliterating dead space and in preventing inversion of the wound edges. Silk, cotton or fine alloy steel wire may be used as skin sutures (Fig. 51). Wound clips are also a useful and a rapid method of skin closure in some areas.

Pressure dressings are made by the application of several layers of folded gauze held in place by adhesive straps or bandage and adhesive. Such dressings not only act as a protective covering but they are also a further aid in preventing wound collections. In some dressings in which it is essential to maintain pressure over a considerable period of time, sponge rubber or mechanics' waste may be incorporated in the dressing and held in place with snug bandages. When the integrity of the wound is endangered by move-

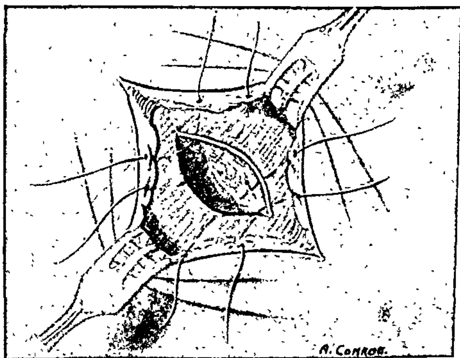


FIG. 50. Obliteration of dead space in wounds. In certain types of wounds it is necessary to obliterate dead space in the deeper tissues before approximating the skin edges. This is accomplished by interrupted buried sutures that include both the lateral wall and the base of the wound. Frequently it is wise to insert all the sutures before tying any of them, otherwise difficulty may be encountered in catching the base of the wound in the last few sutures.

ment of the part, a splint is applied for 4 or 5 days to enforce immobiliza tion

By following the details of this method of wound closure, it is nec essary only occasionally to ligate any bleeding points, and it is almost never necessary to insert a drain.

Infected Wounds. When incisions are made for drainage of infected areas, the advantages of hemostasis produced by tourniquets or wound tension are again evident. As soon as the pus-containing cavity is entered, retractors are placed within the wound edges and the liquid pus is removed with gauze sponges or by aspiration. The wound is then inspected and laid open throughout the entire length of the pus cavity. Usually, a considerable capillary ooze is encountered, but this is easily controlled by packing and pressure. Occasionally, a large spurt ing vessel must be caught and tied. The wound should then be filled with plain or iodoform gauze and a pres sure dressing applied The bleeding, which may *seem to be profuse*, will soon stop under this treatment.

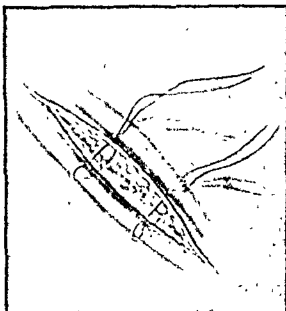


FIG. 51. Interrupted vertical mattress sutures. These sutures are inserted by passing the needle through the wound edges at a distance from the incision and then returning the needle through the wound edges close to the incision. This type of suture prevents inversion of the wound edges, it is a further aid in the obliteration of dead space, and it prevents wound collections by *permitting the escape of serum and* blood between the sutures.

5.

Postoperative Care

CARE IMMEDIATELY AFTER OPERATION

Care after an operation must be as prudently supervised on an ambulatory patient as on a hospital patient. The surgeon must be familiar with the complications which may occur and should instruct the patient as to precautionary measures. Immediately following the operation there will naturally be pain due to the operative wound. After operations under local anesthesia, this pain may not appear until some time later. It is wise, therefore, to advise the patient to go home immediately to permit the homeward journey to be made without pain. In operations performed under general anesthesia, there is discomfort as soon as recovery from the anesthetic takes place. Recovery is almost immediate when the operation has been performed under Vinethene anesthesia, so that usually the patient experiences pain before he leaves the operating table. However, since the operations for which general anesthesia is used are usually performed for infective lesions, the pain after operation is little more, and often less, than before operation.

INSTRUCTIONS FOR HOME CARE

When the operation has been a relatively extensive one, morphine sulfate, gr. 1/6, is often administered before the patient leaves for his home, and a prescription is given him for additional tablets to be taken by mouth every third or fourth hour if necessary for the relief of pain. In other cases, the patient is instructed to lie down and elevate the part, and acetylsalicylic acid is prescribed, to be taken in 10-gr. doses every 2 or 3 hours as needed.

In operations in which primary closure of the wound by suture is not possible, as in cases of excision of an ingrown toenail or incision of an abscess, hemostasis is frequently not complete when the patient leaves for his home, in spite of the fact that pressure dressings were applied. Clotting usually takes place rapidly, however, and bleeding is never dangerous. Nevertheless, it is wise to warn the patient that there may be some slight oozing from the field of operation for a short time, and that this may easily be controlled by rest of the part in an elevated position. When hot moist dressings are to be applied to inflammatory areas in which incisions have been made, the patient not infrequently becomes alarmed at the appearance of the bloody stains on the bandages. The patient should be warned that this discoloration of the solution in the first few soakings of the bandage is to be expected.

In the treatment of ambulatory patients, a final and a most important word of instruction must invariably be given; namely, that if at any time

the patient notes unusual bleeding, increase in pain or any other added or unusual symptom, he should communicate at once with the surgeon who performed the operation. The surgeon will be called very infrequently if his work has been performed carefully and thoroughly, but there are occasions, as in hemorrhage from a hemophiliac following a simple incision and drainage, when the patient may have to be brought back to the operating room for further care. It is important that the surgeon who performed the operation be called, and not some neighboring physician, who would not be familiar with the lesion, the details of the operative procedure and the after-care.

DRESSINGS

The original dressing applied at the time of operation should provide sufficient absorptive material to take care of the wound secretions for at least 24 to 48 hours, and it should be applied well enough to remain in place for that period of time. It should provide sufficient pressure to aid in producing hemostasis, but *it should not* be so bulky as to be awkward and inconvenient for the patient. Experience in the care of *operative wounds in* ambulatory patients permits the surgeon to gauge very well the amount of absorptive dressing necessary in a given wound. Following incisions of infected areas in which packing has been inserted, gauze dressings or the commercial type of gauze dressing containing a film of cotton should be applied over the wound. Pressure is obtained by placing one or two strips of adhesive on the skin across the dressing and applying a firm bandage When the wound is on one of the extremities, especially the upper extremity, a splint is often incorporated in the dressing.

When warm solutions are to be applied to the dressing, more than ordinary care must be taken in its fixation. Some surgeons believe that adhesive cannot be used on such a dressing, our experience has been that it has a distinct advantage if it is properly applied. If adhesive strips are so applied that the end of the strip lies on the back of another piece of adhesive, moisture does not often loosen it. Adhesive can best be applied in longitudinal or fixation strips and held in place by anchoring or circular strips. Dressings applied in this way will remain in good condition for 3 or 4 days in spite of the frequent use of hot moist applications.

RE-DRESSINGS

The time for re-dressing depends upon the type of wound or, more exactly, upon the amount of secretion from it.

Dressing Clean Wounds. In clean wounds, unless pain, swelling or other evidences of infection appear, re-dressing is not necessary until it is time to remove the sutures. In all clean wounds, therefore, the patient is instructed to return in 3 days or sooner if the lesion does not become increasingly more comfortable. At the third-day visit, the dressing is inspected. If it is not soiled and there is no discomfort in the region of the wound, the patient is asked to return on the fifth to the seventh day for removal of the sutures. When there is some soiling of the superficial parts of the dressing, the gauze on top may be changed, care being taken not to disturb the underneath layers, where there is usually a brownish hard stain

of dried blood which acts as an excellent splint for the wound.

When the patient complains of some discomfort in the area of the wound and, on inspection of the bandage, some edema of the tissues is noted, the dressing is removed and the wound is inspected. This state of affairs is usually found in cases in which there has been considerable dissection in the subcutaneous fatty tissues and a low-grade localized cellulitis has resulted. In such cases it is rarely necessary to open the wound, although removal of one or two sutures to relieve tension may be helpful. Experience has shown that this type of wound reaction will subside in 24 to 48 hours by the application of 70 per cent alcohol on the dressing, and the patient is instructed to apply this three or four times a day.

At the patient's second visit on the fifth to the seventh day after operation, the sutures are removed. In cases in which the integrity of the wound may be affected by movement of the part, splints are included as a part of the dressing for a week or so after removal of the sutures. Occasionally, it is necessary to continue the alcohol dressings for several days after the sutures are removed. When wet dressings of alcohol are used, the same precautions as to the application of adhesive should be followed as are recommended in the case of hot moist dressings.

It will be noted that none of the commonly used antiseptics is applied in the care of clean wounds, and, when alcohol moist dressings are used, it is with the idea of providing an easily available evaporating lotion which will not cause maceration of the skin.

Dressing Infected Wounds. The patient with an infected lesion should be asked to return for dressing on the second day after operation. As a rule, it is unwise to change the dressing on the day following operation, as to do so usually sets up renewed bleeding and the secretions are usually not excessive enough to demand a change of the dressing.

On the second day after operation, the superficial dressings are removed and the wound is inspected with the packing or the drain still in place. The surgeon then decides as to the type of dressing to be applied, and this must be done before the instruments and the dressing tray have become soiled. He should be provided with sufficient cotton balls soaked in hydrogen peroxide to wash away the dried secretions on the edge of the wound and to use as sponges in removing purulent secretions from the wound itself. A few alcohol sponges are useful for a final cleaning of the skin round the wound. If packing is to be replaced, he should reserve sterile instruments for removing packing from its sterile container and for cutting it with sterile scissors without contaminating the remainder. Unless the packing in the wound seems to be acting as a plug and preventing drainage of the wound secretion, it is usually wise to leave it in place or to remove it only in part at this dressing because, at this time, a sufficient amount of inflammatory induration has not developed in the walls of the wound to keep its lips from falling together. It should be mentioned in passing that, when gauze packing is adherent to the edges of the wound, considerable pain is experienced by pulling it away at this second-day dressing, whereas it usually is easily

removed without pain at later renewals of the dressing.

After this initial dressing, the interval between future dressings depends to a great extent upon the amount of secretion. If it is profuse, daily dressings are necessary, whereas, if the breakdown of sloughing tissue is slow, dressings may be maintained for 2 or 3 days. Usually, at the second dressing all packing is removed from the wound, and by this time, if an adequate incision has been made, an opening of sufficient size remains. Unless the infected area is deep, there is no necessity for reinserting packing or other drainage material. The inflammatory induration in the walls of the wound will not permit its closure until all the purulent material has been discharged. When the wound is exposed, an effort should be made to remove all the liquid necrotic material and as much of the loosened area of necrosis as possible.

Two methods are of particular value in the removal of liquid material. The easier and the more painless method is the irrigation of the wound with warm saline solution. The glass syringes with rubber bulbs have been found to be most useful in this connection; they may be handled with one hand and the force of the stream regulated so that the solution may be forced with good pressure into the deeper recesses of the wound cavity. This method of cleaning the wound is of particular value when the wound is deep and when there is considerable sloughing fascia and connective tissue. In surface infections, the liquid secretion and the slough may be removed by mopping the wound surface gently with a cotton sponge moistened in saline or peroxide of hydrogen. Once the wound and the surrounding tissues have been cleaned of purulent material, areas of sloughing tissue which has not yet liquefied may be seen. Often these areas may be loosened gently by applying slight tension with forceps, or they may be cut away carefully with the scissors from the surviving tissue adjacent to them. If the sloughs are not loose, it is better to leave them alone until the next dressing rather than to run the risk of causing the patient pain and of setting up bleeding.

When the wound and the surrounding tissues have been cleared of purulent secretions, it is often well to bathe the skin round the wound with 70 per cent alcohol on a cotton sponge. This may prevent the infection of the hair follicles in the adjacent skin and the furunculosis which not infrequently occur. When the secretion is profuse, an excoriation of the surrounding skin may develop. This is treated by the application of a small amount of zinc ointment after it has been throughly cleaned and bathed with 70 per cent alcohol.

Dressings are continued daily or every other day as long as there is much drainage from the wound. Moistening the dressings prevents crusting and permits the escape of the wound secretions. It should be borne in mind, however, that the best results are obtained and maceration of the skin is avoided by permitting the dressing to dry at frequent intervals, so that after the fourth or the fifth day the dressings need be moistened only once or twice a day.

As soon as all the slough has disappeared and the wound has become covered with a base of granulation tissue, an effort may be made to hasten

the closure of the wound by pulling its lips together with flamed adhesive straps. Generally, this is necessary only in cases in which there has been considerable skin slough, as, for instance, following incision and drainage of a carbuncle. In a few such cases, epithelization may be hastened by the application of pinch skin grafts (Fig. 52).

TECHNIC OF DRESSING

The setup for dressings is relatively simple, but there are several points which experience has shown to be worth while. The dressing table should be fitted with a stainless steel, a glass or an enameled top If the table has a second shelf, the materials for dressings can be kept in glass jars, otherwise they may be stored in the drawers of the table. These include 1-, 2- and 3-in. bandages, the large-sized (4 x 8 in.) dressings sterilized in packages of two or three wrapped in a paper napkin, and small-sized gauze compresses (3 x 3 in.) also wrapped in paper napkins and sterilized in packages of three. On the top of the table may be kept four 3 x 3 in. glass jars: the first containing cotton balls soaked in benzene for the removal of adhesive from the skin; the second containing cotton balls soaked in 70 per cent alcohol; the third, cotton balls soaked in hydrogen peroxide; and the fourth, dry cotton balls.

For each dressing there should be a sterile tray with the following sterile instruments: scissors, forceps, hemostat and probe (Fig. 53). The trays which have been found to be most convenient are of enamel or of Allegheny metal, 3 x 8 or 6 x 8 in. They may be made up by placing the instruments between layers of gauze compresses and sterilizing them in the autoclave. When an autoclave is not



Fig. 52. Pinch grafts applied to carbuncle of neck following disappearance of necrotic slough. This procedure hastens epithelization in large areas of granulation tissue.

available, the instruments and the tray may be boiled in the sterilizer, except the scissors and other sharp instruments, which are sterilized in alcohol or sterilizing solution. When the tray is removed from the sterilizer with sterile lifting forceps, a sterile 4 x 8 in. gauze compress is placed in it. The instruments are then transferred from the sterilizer to the tray with the sterile lifting forceps and may be covered with a lid or another sterile dressing. Two or three such trays may be kept in readiness, and, after use, the instruments and the trays may be resterilized. It is an advantage to keep on one tray, in addition to the above instruments, 2 Allis forceps, 2 towel clips and a toothed forceps. These are then at hand if needed in a hurry for a dressing or for some minor operation.

For the ordinary dressing, our preference has been for the smaller sized instruments. Scissors 5-in. long are adequate, and straight scissors last longer and are more serviceable than curved ones. Plain forceps with serrated tips 4-in. in length are cheaper and more convenient than are the

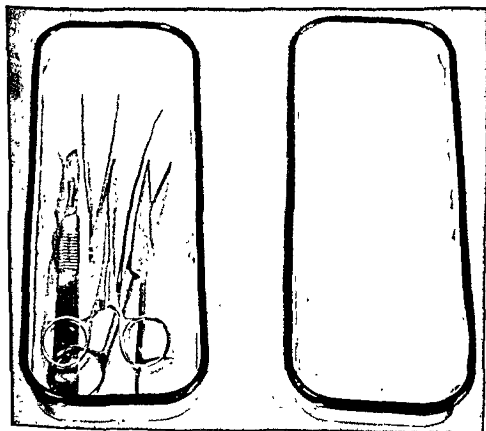


Fig. 53. Simple tray used in dressing wounds in ambulatory cases. This tray contains the following sterile instruments: scalpel, forceps, hemostat, probe, scissors. They are placed on a piece of sterile gauze in the tray and covered with a second piece of sterile gauze until ready for use, as shown on the right.

usually used 6-in. instruments. The hemostats may be ordinary 4- or 6-in. ones, and the best probes are those with round ends and 6 in. long.

Before changing a dressing, the hands should be washed thoroughly with soap and warm running water. Bandages and adhesive should never be cut with scissors from the sterile tray but with bandage scissors. After removal of the bandage and the top layer of dressing with the fingers, the wound is exposed. If any part of the gauze is adherent to the wound, it should be left in place and the remaining part of the dressing cut away with bandage scissors and discarded. All soiled dressings should be placed immediately in a waste receptacle, not on the sterile tray or on the dressing table. The remaining part of the dressing should be performed entirely with instruments. With the forceps, a sufficient number of dry cotton balls or peroxide sponges should be transferred from the jar to the sterile tray, and then any portion of the dressing adherent to the wound should be removed gently with the forceps. Next comes the cleaning-up process, which should be carried out as described above and performed entirely with instruments. It is well to try to keep one instrument, usually the hemostat, uncontaminated, so that, if necessary, it can be used to transfer additional sterile supplies to the sterile tray. When the dressing is completed, the wound is overlaid with sterile gauze compresses, which are transferred from the freshly opened package to the wound with the forceps or a hemostat. The instruments are then laid aside, and the dressing is completed with bandage and adhesive. By this technic, secondary infection is avoided as much as possible, and dressings of even large wounds may be performed easily with an aseptic technic without the necessity for rubber gloves.

• 6 •

Dressings and Bandages

REQUIREMENTS AND PRINCIPLES OF DRESSINGS FOR AMBULATORY PATIENTS

The requirements of dressings and bandages for ambulatory patients are somewhat more exacting than are those for patients in hospitals or at home in bed. In addition to fulfilling the requirements of any dressing, which are to absorb secretion, protect the part, serve as wet compresses and exert pressure, they must be comfortable and not burdensome or inconvenient. Also, they must stay absolutely in place until time for the next dressing, and they should permit the patient as far as possible to resume or continue his normal activities with the least inconvenience.

In the various books on bandages and dressings will be found the standard (and perhaps the outmoded) bandage forms and turns. Here it is intended to give in detail only the methods of bandage and dressing application that have proved their value in ambulatory surgery.

TYPES OF DRESSINGS

The Ordinary Dressing. The ordinary, so-called dry, dressing applied to a traumatic wound or a lesion following the subsidence of an infection is the simplest form of dressing. It would seem to be almost superfluous to point out that in this, as in any other form of dressing, sterile gauze should be applied next to the wound. However, it has been the author's experience many times to encounter dressings in which unsterile bandage gauze had been folded over itself and used for this purpose, in spite of the fact that sterile gauze compresses had been available. In the application of a simple dry dressing, as in the application of all dressings to ambulatory patients, it should be remembered that the dressing need be no larger than the wound to be covered. It is, therefore, quite permissible, and even to be recommended, that the sterile gauze be cut with sterile scissors, to fit the wound rather than that a large dressing be applied to a small wound. The gauze may be held in place by either adhesive or bandage, depending on the situation of the wound. Many small wounds, such as those on fingers or toes, are much better dressed with a small square of sterile gauze held in place by circular strips of adhesive than by trying to anchor the dressing with a cumbersome gauze bandage (Fig. 51). When dressings are applied to parts in which there is considerable movement, such as the leg or the thigh, it is best to hold them in place with 2 or 3 transverse strips of adhesive that almost, but not quite, encircle the part. An overlying bandage may be applied to add pressure and support (Fig. 55). In dressings applied to regions near joints, it is wise

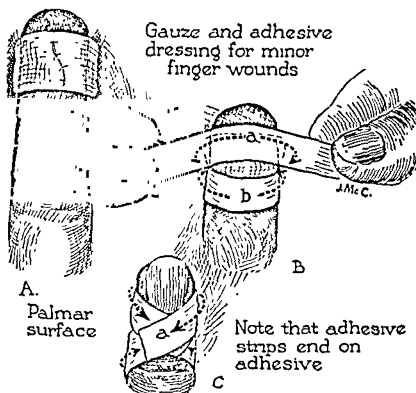


FIG. 54 Method of application of small dressings to the fingertip, adhesive being used instead of bandage.

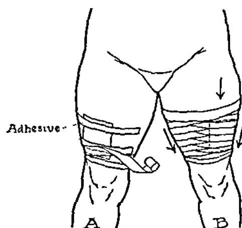


FIG. 55 Method of using adhesive strips over gauze dressings before applying bandage on conical parts. With the adhesive anchorage underneath the bandage, the dressing will stay in place very well. without it, the dressing tends to slip downward.

to place the adhesive so that the normal action of the joint will not put tension upon it. To do this it is often well to move the joint in its various positions while inspecting a dressing, after which some readjustment of the adhesive strips may be necessary.

The Hot Wet Dressing. Hot moist dressings are applied in the treatment of inflammatory lesions both before and after incision. A more complete discussion of the use of moist heat and of hypertonic solutions will be given in the chapter on the treatment of infection and inflammation. Suffice it here to say that the requirements of a wet dressing, whether or not it is one which can be completely moistened with a warm solution, are that it be kept warm for a considerable period and that it be one from which drying

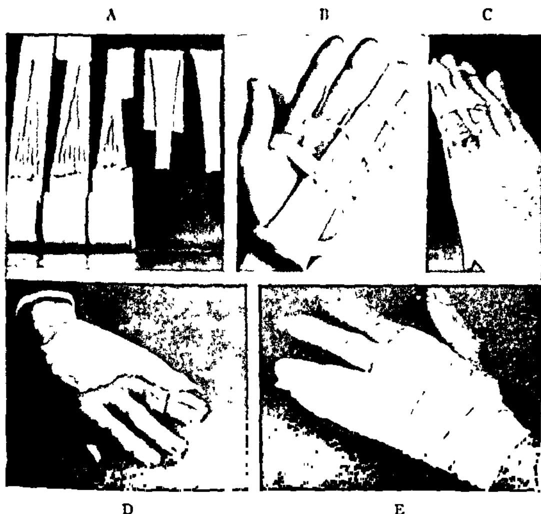


Fig. 56. Methods of applying hot moist dressings for a furuncle of the dorsal surface of the proximal phalanx. The swab stick splint (A) is made and applied to the hand with adhesive (B). The fingers are separated with gauze (C); sterile gauze dressings are applied and overlaid with wax paper (D), and the entire dressing then is enclosed in gauze bandage held in place with adhesive circles (E). (Ferguson, L. Kraer [A] Pennsylvania M. J. 40:909-914, [C, D and E] Am. J. Surg. 41:57-66)

may take place. In addition, because the patient is ambulatory, some provision must be made to protect his clothing with wax paper, cellophane or oiled silk, and special attention must be paid to the security of the dressing. In almost all hot moist dressings of the extremities, a splint or some other form of immobilization is also employed to keep the part at rest.

The inflammatory lesion is overlaid with several gauze compresses. These are applied dry and are so placed and built up over the wound as to provide a large area of gauze, fully ½ in. thick at its center, which spreads for a considerable distance on all sides of the infected wound. In order to keep the moisture and the heat from escaping, a protection of 1 or 2 layers of crum-

pled wax paper or of cellophane is then applied over the compress (Fig. 56). In some cases a rubber tube, *through which solutions may be* added, is placed over the gauze and brought out to the surface above the protective covering. The whole is then securely wrapped with gauze bandage, the splint being incorporated in its outer layers. Finally, the securing strips of adhesive are applied in circles. When the dressing is applied to the hand or the forearm, a sling is provided. The patient is then instructed to moisten the gauze compresses with a designated solution. This is best done with a small rubber ear syringe, the nozzle of which can be inserted at one end of the bandage and the part so held that the solution will moisten the gauze compresses by gravity and by capillary attraction. When a rubber tube is used, the solution may be introduced through it. This directs the solution on to the gauze compresses, and, as a rule, a smaller amount of solution may be used because there is no doubt about its getting to the right place. Dressings do not need to be moistened oftener than 3 or 4 times a day

When hot wet dressings are to be applied to large areas, as for instance in the treatment of a lymphangitis of the arm, and when there is no open wound, it is often possible to use nonsterile materials such as absorbent cotton or surgical lint. These two materials make excellent large absorbent applications. The arm is flexed at a right angle, and the entire arm from hand to shoulder is covered with the cotton or lint and then with crumpled wax paper, which in turn is held in place by bandages In such cases, openings may be left in the wax paper and marked on the surface of the bandage; through these the patient later may moisten the dressing at intervals.

Dressings for Traumatic Lesions. In dressing traumatic lesions an effort should be made not to disturb the wound any more than is necessary. Therefore, an application is made which may remain in place until the wound is healed. Experience has shown that paraffin mesh gauze or wide-mesh gauze impregnated with petrolatum best fills this requirement. This is applied so as to extend well beyond the wound, sometimes in two or more layers, and the gauze dressing is laid over it. At subsequent dressings, only the overlying gauze is removed unless there is some reason for disturbing the protective covering of the wound. Splints are invaluable, at least in the early treatment of such lesions.

DRESSINGS FOR INDIVIDUAL PARTS

Finger and Toe. The usual type of dressing suggested for the finger includes an anchoring turn or two at the wrist and then a spiral or a spiral reverse of the finger, the bandage being brought up across the dorsum of the hand. Experience with this dressing has shown, however, that it has a tendency to become loose, and that at the turn of the bandage at the wrist and over the dorsum of the hand it soils rapidly, frays and gets in the way. A much more useful dressing consists of applying 1-in. bandage over a sterile gauze pad. The bandage is circular or spiral, and it is made to cover only the part of the finger containing the lesion.

For dressings of the fingertip, as, for instance, following an incision and drainage of an infection of the distal closed space, the 3-in. sterile gauze

compress is cut as shown in Figures 57 and 58. The loose ends are then folded over the fingertip and the dressing is completed with circular turns about the gauze and recurrent turns over the tip of the finger, which are finally held in place by additional circular turns. The bandage is then anchored with a longitudinal adhesive strip held in place by circular anchoring strips. In many cases it is advisable to apply a hairpin splint as extra protection (Fig. 59).

In lesions at the base of the finger, as, for instance, a furuncle of the proximal phalanx, there is frequently a considerable amount of associated cellulitis and edema over the dorsum of the hand. In these cases, it is well to apply a splint that includes the adjacent finger. The splint which has been found to be most useful in this

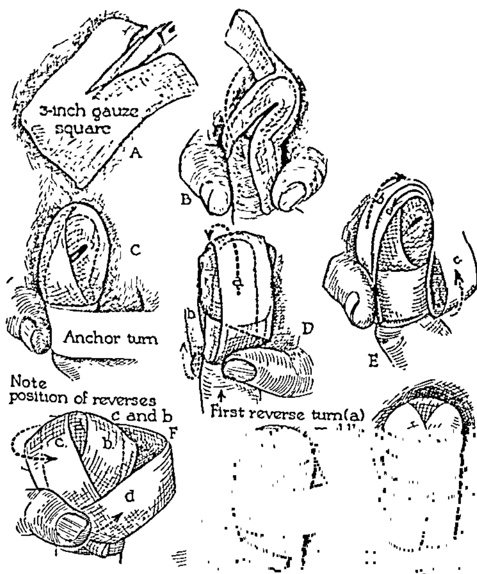


FIG. 57. Dressing for the finger.

connection is the swab-stick adhesive splint. This is applied with 2 or 3 circular turns of adhesive which include the sterile gauze over the lesion. More gauze is then applied as indicated, and the whole is held in place by 1-in. bandage about the palm and the proximal fingers. Circular turns of ½-in adhesive anchor the dressing (Fig. 56).

Dressings for the toe are applied in the same manner as that described for the finger.

The Hand. Dressings for the palm and the dorsum of the hand are best applied with 2-in. bandage, and these must be anchored by figure-of-eight turns round the hand and the wrist (Fig. 60). When splints are used with this dressing, they should be long enough to include the entire length of the fingers and to extend upward

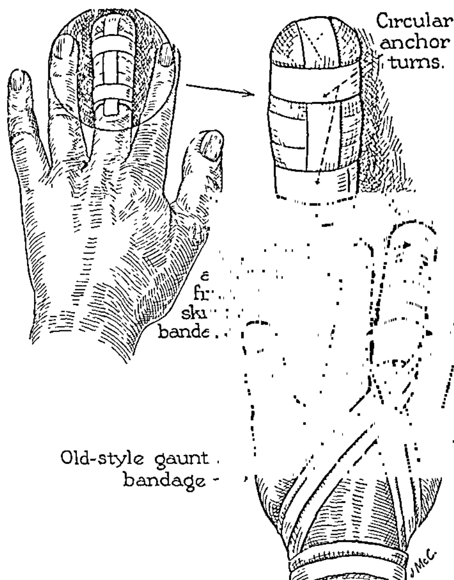


Fig. 58. Finger dressing.



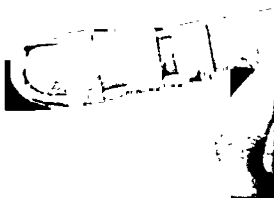


Fig. 59. (*Left*) Hairpin splint. This splint is easily available and useful in immobilizing fingers. It is small, compact and molds readily to the part. (*Right*) Hairpin splint applied to the finger. The splint is molded to fit over the finger dressing, covering the palmar surface of the finger and the fingertip. It is held in place with a longitudinal strip of adhesive, which begins and ends on the skin and is anchored by 3 circular turns of adhesive applied in such a way that the ends lie on adhesive. In this way the dressing may be soaked without fear of its coming loose. (Ferguson, L. Kraeer: Pennsylvania M. J. 40: 909-914)

beyond the midforearm. Padding should be provided in the palm to allow the fingers to lie comfortably in partial flexion.

The Forearm. Dressings of the forearm are held in place with 2-in. gauze bandage applied in spiral and spiral-reverse turns. They should be anchored by diagonal strips of ½-in. adhesive applied to the skin above and below the bandages; these in turn are fixed by circular turns of ½-in. adhesive (Fig. 61).

The Elbow. For dressings at the elbow, large gauze compresses are used, usually 4 x 8 in. in size. With the elbow flexed at a right angle, these are anchored by a circular turn or two of 2-in. bandage on the forearm side. The bandage is applied in figure-of-eight turns, one loop above and one below the elbow until the area is covered. Anchoring longitudinal strips of ½-in. adhesive are applied to the skin above and below the bandage, and fixation circular turns are used to hold these in place (Fig. 62).

The Upper Arm. Dressings here are applied in the same way as to the forearm, except that in this area reverse turns are less often necessary.

The Axilla. Dressings in this area are most often applied for superficial infections or abscesses. After a sufficient amount of gauze has been used to cover the wound, one large piece of gauze should be spread out to cover the entire underlying dressing and to extend for a distance of about 3 or 4 in. downward along the lateral chest wall and for the same distance along the inner side of the upper arm. A strip of 1-in. adhesive is then placed across the middle of the gauze in the

uppermost part of the axilla so that the cut end of the adhesive is long enough to reach over the top of the shoulder (Fig. 63, I). The arm then is placed down against the side of the chest wall, and the adhesive is attached to the skin in front and back, one end overlying the other over the acromion process (Fig. 63, II). The arm then is raised, and a second strip of adhesive is applied over the gauze and fixed front and back over the chest wall. A third strip is applied in the same manner over the gauze round the upper arm (Fig. 63, III).

The Shoulder. A spica bandage is used occasionally for the application of dressings to the top of the shoulder and the upper chest. It is applied in what amounts to figure-of-eight turns,

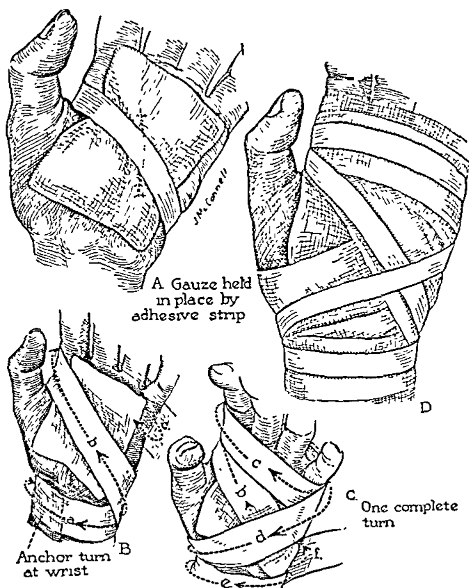


Fig. 60. Hand dressing

beginning in the axilla of the normal side and coming up across the anterior portion of the chest and the shoulder and round the arm from behind forward. Sometimes a circular turn is made round the arm in the first lap of bandage and then the roll is carried up across the anterior surface of the shoulder and across the back to its original starting place in the sound axilla. These turns are repeated, crossing each other higher and higher on the shoulder, each succeeding turn overlapping about one half until sufficient turns have been applied to cover the desired area. A 3-in. gauze bandage is best for this purpose. The spica is fixed with 1-in. adhesive strips (Fig. 61).

The Neck. Dressings in this area are most often applied for the furuncle or the carbuncle type of infections at the back of the neck, or for abscesses of the cervical glands in

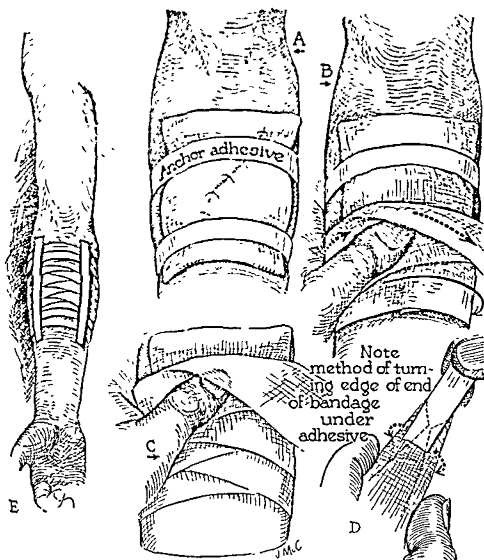


Fig. 61. Forearm bandage dressing.

the anterior neck. After the application of a sufficient number of gauze compresses, the dressing is held in place by circular turns of 2-in. gauze bandage. This dressing cannot be applied well with the patient lying down Therefore, when it is to be applied immediately after operation, it is best to hold the dressing in place until the patient has recovered sufficiently from the anesthetic and can sit up. The dressing is usually wider at the site of the lesion than at other portions of the circumference of the neck, and the bandage should be so applied at this area as to cover completely and to hold in the top and the bottom of the gauze compresses. The bandage is anchored in place by ½-in. adhesive strips. Experience has shown that it is more secure if the adhesive strips are applied first at the site of the lesion in an elliptical shape at the top and the bottom of the band-

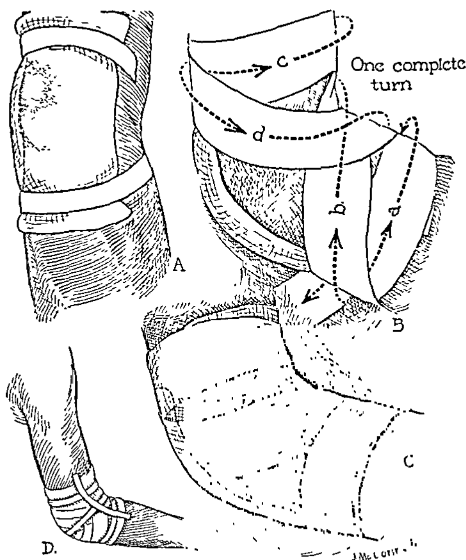


Fig. 62. Method of applying a dressing and bandage at the elbow.

age, the ends of which are then covered by a circular strip of adhesive applied round the middle of the bandage. After the application of such a dressing, it should be inspected carefully to make sure that it is not tight enough to cause compression of the veins of the neck, with resulting venostasis of the face and the head. Occasionally it is necessary to snip the bandage a little in several places to relieve this compression (Fig 65).

The Lower Face and the Jaw. As a rule, ordinary dressings of the face and the jaw may be applied with gauze and adhesive, or simple Whitehead's varnish dressings (see p. 238) may be applied. In some instances, however, and especially following trauma or operation, a dressing must be held in place with bandage for compression or for the application of hot wet dressings. In these cases, a modified type of Barton bandage is best, a 2-in. gauze bandage being used. After the application of the gauze dressing, the end

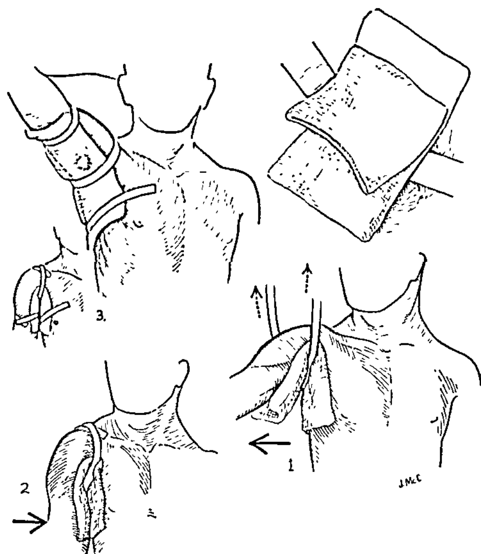


Fig 63 Method of applying a dressing to the axilla, using adhesive.

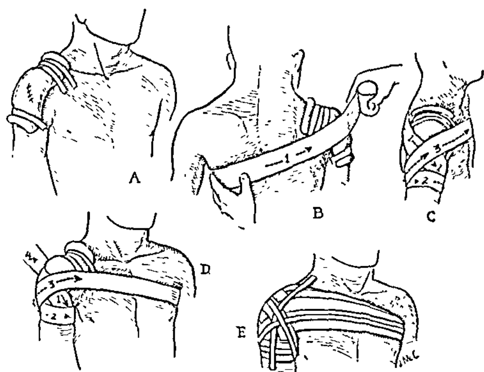


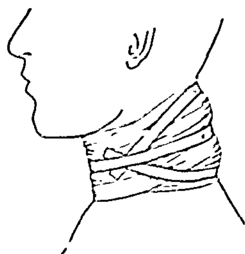
FIG. 64 Application of a dressing to the shoulder, showing the use of the spica bandage of the shoulder.

of the bandage is placed at the back of the neck and the roll is carried diagonally across the side of the head toward and just above the ear on the involved side. Then it is carried across the head and downward in front of the ear on the opposite side of the face, underneath the chin and upward across the gauze dressing in front of the ear; it crosses the previous turn in the mid-line of the scalp and descends over the side of the head above the ear to its original starting point. The bandage is then carried round the neck, either on or below the chin, as the occasion demands, to the original starting point in the back of the neck. This comprises one turn of the bandage; 4 or 5 such turns are usually used, overlying or overlapping each other as the occasion demands.

The bandage is made secure and is pulled away from the patient's eye by bandage ties, which are inserted with a hemostat under the turns of the bandage opposite the eye on each side. An even easier method of inserting them is to put them in place before the bandage is applied (Fig. 66). When these are tied, they not only pull the bandage away from the eye, but also, incidentally, increase the compression applied in the original turns. It is useful to apply the same sort of tie at the site at which the bandage crosses at the top of the head. The bandage is completed by tying the ends in one of the tension ties. An alternate method of applying a bandage to the lower face and the jaw is illustrated in Figure 67.

The Back of the Neck and the

Head. Dressings of the back of the neck and the lower scalp are held in place best by figure-of-eight turns round the head and the neck. The bandage is started at the back of the neck, carried forward round the head and above the ears to its starting place, thence round the neck and back again to its beginning. Several such turns are applied to cover the compress. The bandage is strengthened by a figure-of-eight turn of 1½ in. adhesive applied over it (Fig. 68).


Fig. 65. Neck dressing. Note method of applying adhesive strips.

The Scalp. Most traumatic or operative wounds of the scalp may be treated by the application of a Whitehead's varnish dressing. When the ooze

Fig. 66. Barton type of bandage for securing and applying compression for lesions of the lower face and the jaw. Note method of tightening bandage with anchoring ties.

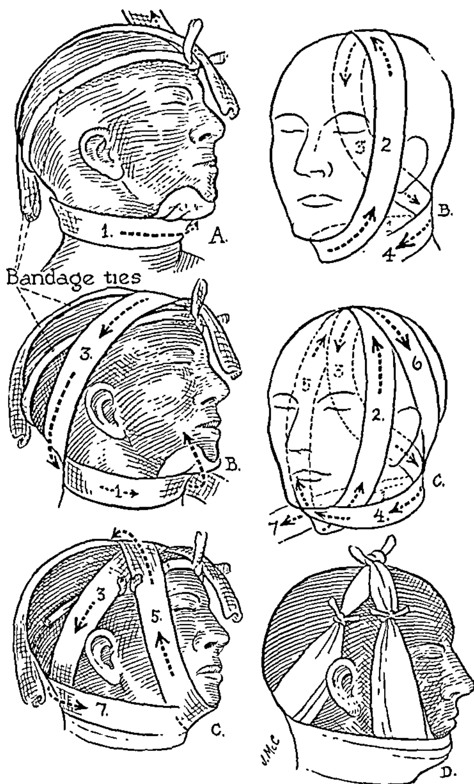


Fig. 67. Alternate method of applying bandage turns for securing dressings of the lower face and the jaw.

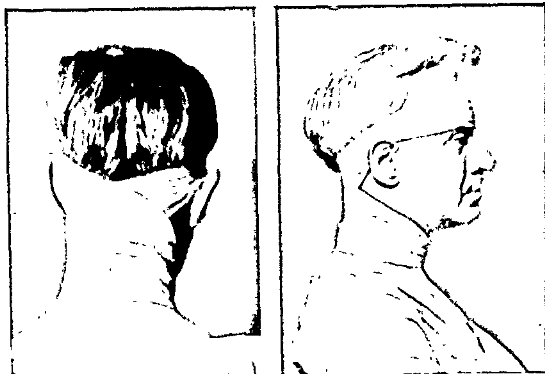


Fig. 68. Figure-of-eight dressing of the head and the neck for lesions of the back of the neck.

has been controlled by digital or palmar pressure, the wound is painted with a cotton swab saturated with the varnish. A small amount of fluff cotton is then applied over the wound while the varnish is still moist, and the cotton is moistened with additional varnish. This dries rapidly, and, as a rule, no further dressing need be applied. Occasionally, there is a slight ooze, which may be absorbed by the application of a small amount of gauze over the wound for a short time The Whitehead's varnish type of dressing may be used for most traumatic or operative wounds of the head, the face and the neck (Fig. 144).

A simple method of applying small dressings to the scalp is by using the hair to anchor the dressing in place.

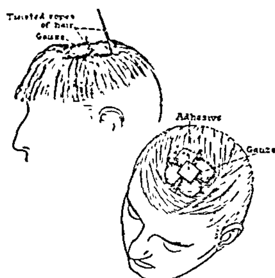


Fig 69. Method of securing small dressings on the scalp by twisting hair and holding it over the dressing with a small piece of adhesive.

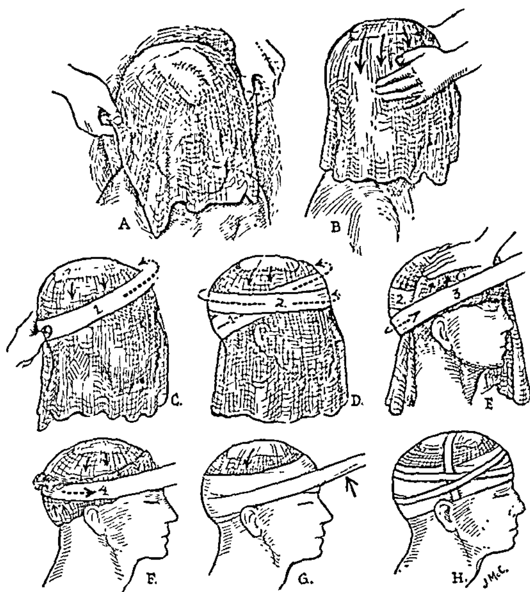


Fig. 70 Steps in the preparation of a Frazier head dressing for lesions of the scalp

Fradkin suggested that the hair be tied with silk over the dressing. More recently Cogswell and Thomas have applied the dressing in the same way, except that they have used a small piece of adhesive to hold the binding hairs in place instead of tying them with silk. This method is very convenient, and it may be changed at will, either by cutting off the hair or by moistening the adhesive with ether or benzene (Fig. 69).

When there is considerable secretion from an infected wound, or hemorrhage demanding pressure, the Frazier type of skull-cap dressing is most satisfactory. Gauze compresses are placed over the lesion, and the entire

skull is then covered by two of the 4 x 8 gauze compresses which have been unfolded so as to make a double layer of gauze about 8 x 8 in. These pieces of gauze are held tightly over the scalp by an assistant while the surgeon applies 2 or 3 circular turns of 2 in. gauze bandage snugly round the scalp below the occiput and well down over the forehead (Fig. 70 A D). When the gauze has thus been anchored, it is pulled down snugly in all directions so as to provide pressure over the gauze compress and the lesion. The edges of the gauze are then turned upward and included in additional circles of bandage, some turns of which extend well down behind the occiput and high on the forehead, while others extend low on the forehead and high on the occiput (Fig. 70 E G). Half-inch strips of adhesive are then applied over the gauze across the head from before backward and from side to side. Finally, 2 anchoring circles of 1½ in. adhesive are applied, the first extending well down behind the occiput and high over the forehead and the second passing across the forehead at the lowermost part of the bandage and high up on the occiput (Fig. 70 H). This dressing will be found to give excellent compression and will remain securely in place for five or six days if necessary.

The Breast. These dressings are most often applied for inflammatory lesions either before or after incision. Gauze compresses are placed over the lesion and are held in place with transverse circles of 3 in. gauze bandage. The transverse turns of the bandage are so placed that they lie above and below the breast. As a rule, those turns lying above the involved breast are pulled downward so that they lie below the opposite breast, and those which are applied below the involved breast cross the chest in an upward direction to lie above the normal

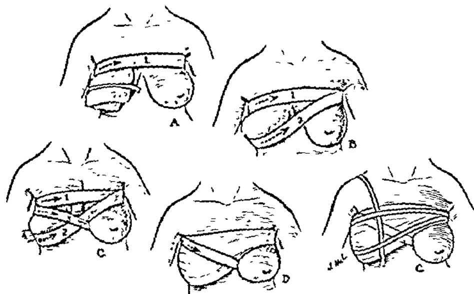


Fig. 71. Method of applying a bandage to the breast.

breast. In effect, the bandage is therefore a cross bandage of the breast. Circular strips of adhesive and, occasionally, longitudinal ones are also applied (Fig. 71).

The Groin. A spica bandage of the groin is usually applied to provide pressure or to hold compresses in place. It may be muslin, but more often a 3- or 4-in. gauze bandage is used. It is begun with a circular turn round the upper thigh and is best applied with the patient standing and holding the legs spread slightly apart. After the first circular or anchoring turn, the bandage is carried upward across the groin and the lower abdomen. A circular turn is then made

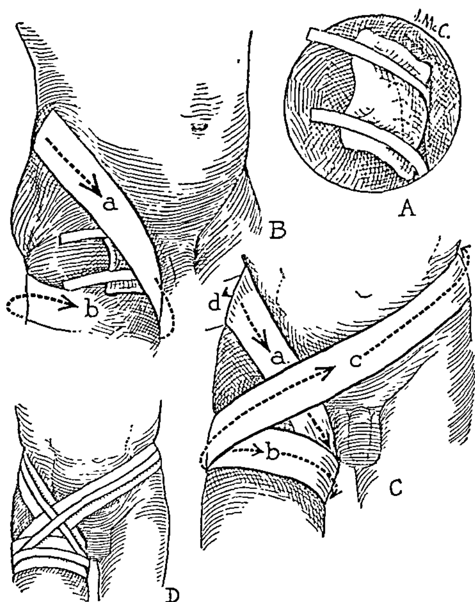


Fig. 72 Method of applying a dressing to the groin.



Fig. 73. Method of applying a dressing to the groin using elastic adhesive. This gives firm compression and does not necessitate a bandage round the abdomen; therefore, it is more convenient and is especially serviceable following ligations of varicose saphenous veins.

round the abdomen and downward across the groin to the thigh. This constitutes one turn of the bandage; several such turns are applied and the bandage is anchored with a similar turn of ½-in. or 1-in. adhesive (Fig. 72).

If elastic adhesive is available, a groin dressing is more easily applied as follows: after fixing the dressing with 1 or 2 strips of adhesive, the elastic adhesive is started below and lateral to the anterior spine, and is carried down parallel to and below Poupart's ligament round the thigh to finish on the original turn. The ends of the bandage are fixed with strips of 1-in. adhesive to prevent rolling (Fig. 73).

The Thigh and the Leg. When dressings are to be applied to these conical parts, it is usually wise to fix the compresses in place by 1 or 2 transverse strips of 1-in. adhesive. Then the bandage is applied in the spiral and then spiral-reverse turns until the compress is covered sufficiently (Fig. 55). Two longitudinal strips of adhesive fix bandage to the skin above and below, and the whole is held in place by 2 or 3 fixation circles of ½-in. or 1-in. adhesive. In placing adhesive circles on a conical part, the adhesive should be stretched and applied to the back of the leg first. The cut end is then brought round the leg; to lie flat it must ascend slightly. Dressings are applied to

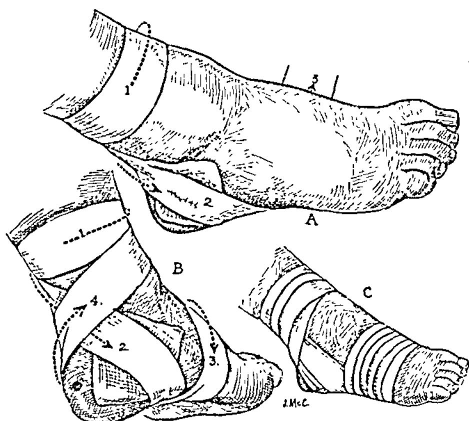


Fig. 74. Method of applying a dressing to the heel.

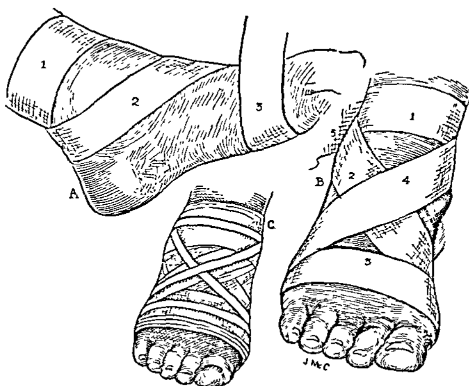


Fig. 75. Method of applying a dressing to the foot.

the opposite side in a similar manner. Three-inch bandage is best for the thigh, and 2 in. is best for the leg.

The Ankle and the Foot. Bandages for the ankle and the foot are most conveniently applied in figure-of-eight turns round the foot and the ankle. Two-inch bandage is usually used, with fixation by 1½ in. adhesive (Figs. 74 and 75).

The Perineum. It is difficult to hold perineal dressings in place with adhesive. The best dressing is composed of one sterile gauze pad over the wound, held in place by the ordinary sanitary pad (Kotex). The elastic sanitary belt is easily available to secure the sanitary pad.

PRACTICAL POINTS IN THE APPLICATION OF BANDAGES

Raveling from the end or the edges of the gauze makes bandages look untidy. If the bandage edges are folded under and an adhesive strip is placed on the end of the bandage, ravelings are not likely to appear (Fig. 76 A).

Bandages round the face are most uncomfortable if ravelings come down over the eyes and the nose. This may

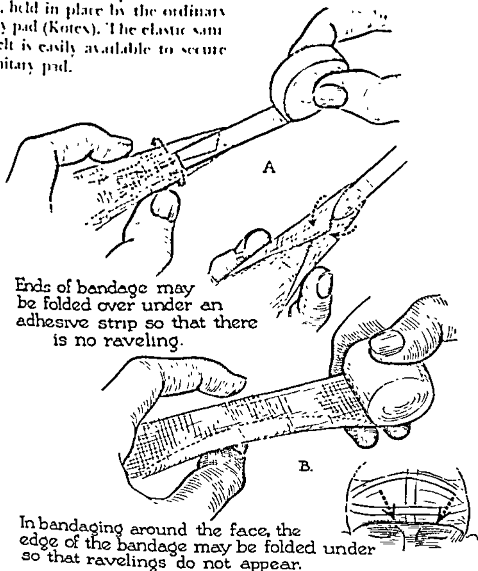


Fig. 76. Points in application of bandage.

be easily avoided by folding in the edge of the bandage as it is placed across the forehead (Fig. 76B).

In the application of adhesive, rather than start one end on the part and then carry it round, it is better to hold the adhesive in both hands and first put on the middle of the strip Then the ends are brought round to overlap each other. In this way, the adhesive follows more easily the shape of the part (Fig 77A).

When adhesive is applied over dressings which may later have hot moist solutions poured on them, the end should lie on adhesive rather than on gauze. If this precaution is taken, any amount of soaking may be permitted without fear of loosening the adhesive (Fig 77B).

READY-MADE DRESSINGS

For protecting small wounds or after removal of sutures, prepared dressings of gauze on adhesive or elastic adhesive are often useful. These may be obtained as cut dressings or in long strips which may be cut as desired Those with the elastic adhesive fit the part more readily.

ADHESIVE

Adhesive has been found to be more convenient when used in cut rolls in widths of ½, 1 and 2 in. It is more easily and economically applied when put on from the roll and not cut until it is in place on the dressing. When adhesive is to lie directly on the skin, it is wise to dry-shave the part; this permits it to attach itself more firmly to the skin and to be removed without discomfort. The portion adherent to the skin may be easily removed with a cotton ball soaked in benzene.

Adhesive is irritating to the skin at times. When it is left in place for long periods of time, that is, 5 or 6 days, minor infections of the hair follicles frequently occur and demand

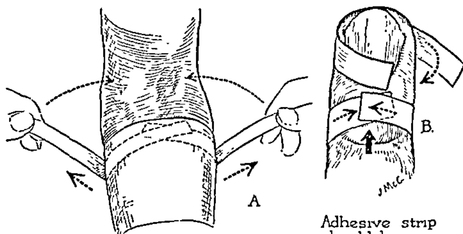


Fig. 77. (A) Application of circular adhesive strips and (B) application of adhesive on adhesive.

its removal. The patient complains of itching and discomfort, indications that a dermatitis has arisen. To prevent this, tincture of benzoin may be applied when adhesive is to be kept in place for some time. The tincture of benzoin is painted on the skin with cotton swabs and is allowed to dry before the adhesive is applied.

Some individuals are sensitive to the chemical compounds of the rubber mixture on adhesive tape. This sensitivity shows itself in a typical and almost immediate erythema and edema of the skin underlying it. In 24 hours the reaction becomes so violent and so associated with itching that it is almost unbearable. When the adhesive is removed, vesicles may appear.

After such an experience with adhesive, the patient usually warns the surgeon that he cannot tolerate it next the skin. It is unwise to attempt to use it when this warning has been given. All degrees of sensitivity are seen, and sometimes one adhesive will produce a sensitivity in a patient whereas another brand of the same type of tape will give no reaction.

When a patient is known to be allergic to adhesive tape, some other form of dressing may be applied. Unna's paste (p. 17) makes a very excellent adherent mixture with which bandages may be applied and held in place without difficulty. Another mixture, which is used in German clinics, is Mastisol. This is composed of gum mastic, 20 Gm., chloroform, 50 cc., and linseed oil, 20 minims. It is a sticky mixture which is adhesive as it dries and apparently does not produce any irritation of the skin. It may be used instead of adhesive for applying superficial dressings and for holding compresses in place under bandages. In some cases cellophane tape may be used instead of adhesive.

TYPES OF BANDAGES

Gauze. The bandages most commonly used are of 32 × 28 mesh gauze. The heavier mesh makes a stronger bandage perhaps, but it contains too much sizing to make application easy.

Muslin. Muslin bandages have long been used where strength of bandage material seems to be essential. In everyday practice they are used very little, except for making T-binders of the perineum, for applying various types of traction cinches for slings and for treating certain fractures. They are most often used in the 3-, 4- and 6-in. widths.

Flannel. Bandages made of outing flannel have been used for years for application to traumatic lesions of the extremities and especially of the joints. These bandages are soft and somewhat elastic. They are used most often in 3- and 4-in. widths.

Elastic. Cotton-webbing bandages which have a marked degree of elasticity are sold by several manufacturers. They are used in 2-, and 3- and, occasionally, 4-in. widths when it is desired to apply elastic pressure, and they far surpass the flannel bandage for this purpose. They may easily be applied in an overlapping spiral, even though the part is conical. These bandages may be used over and over again because washing almost completely restores the original elasticity.

Elastic Adhesive. Several manufacturers have placed on the market cotton-webbing bandages which are overlaid on one side with adhesive. They are most often used in 2-, 3- and 4-in. widths. These bandages are excellent for use when the fixation of a nonadhesive bandage is somewhat difficult. Thus they may be used in the treatment of contusions, sprains, varicose veins, ulcers and so forth.

• 7 •

Treatment of Inflammation Due to Infection

EDWIN J. PULASKI, LIEUTENANT COLONEL, MC, USA

The great majority of acute inflammatory lesions due to pathogenic micro-organisms resolve rapidly under the influence of one or another of the antibiotics now available and proper supportive therapy. Optimal therapy of infections rests upon the special considerations which influence the response of the illness to such therapy. These include host-parasite relationships, antibotic-parasite relationships and antibiotic-host interactions.[7]

HOST-PARASITE RELATIONSHIPS

Surgical lesions caused by micro-organisms may take one of three forms: (1) wound contamination, which may occur any time there is a break in the skin or the mucosal barrier of the external surface of the body, (2) wound suppuration, which connotes lytic bacterial activity with further breakdown of previously devitalized tissues and pus formation, as in full-thickness thermal burns or in abscesses; and (3) invasive infection, which signifies bacterial attack on living tissues, as in spreading cellulitis, lymphangitis and lymphadenitis. Wound suppuration and invasive infection may be coexistent. The special types of bacteria which are usually encountered in surgical infections include the aerobic and the anaerobic hemolytic and nonhemolytic streptococci, the hemolytic *Staphylococcus aureus*, the gram-negative enteric (coliform) bacilli and the sporulating (anaerobic) clostridia.[5] Mixed infections are frequent in open wounds. Less commonly, the causal organisms may be *Bacillus anthracis* (anthrax), *Myobacterium tuberculosis* (T.B), fusospirochetal species, *Actinomyces israeli* (actinomycosis) and other fungi.

Tissue or cellular damage or impairment is the prime requisite for the establishment of most surgical infections. As soon as micro-organisms become implanted in susceptible tissue cells of the body—some of which may be killed or damaged by the injury that caused the break in the continuity—the body defenses meet the invaders in an attempt to wall them off or eradicate them. If there is considerable damage to the tissues, if foreign bodies are present, or if suffusion of blood has occurred, the body defense mechanisms are handicapped and the bacteria are better able to maintain themselves, colonize and become established in the tissues.[1,8,12]

The inflammatory reaction at the site of an infection is the result of

further tissue injury produced by the toxic metabolites elaborated by the invading micro-organisms. The main phenomena are swelling, redness, heat, pain and tenderness. The products formed by the interaction of tissues and bacteria act as irritants to the living cells with which they come in contact, evoking transudation of fluid through increased permeability (edema formation). Leukocytes, as well as erythrocytes, emigrate through the capillary walls into the cellular spaces outside (inflammation). Increased tissue tension results in pain and tenderness, and increased vascularity in redness and heat. The mobilization of leukocytes and the localization of the micro-organisms, as well as the formation of a fibrin network in the tissue, tend to prevent the spread of some types of infection. The spreading tendency of some infections is well known—e.g., those due to hemolytic streptococci and *Clostridium welchii* — while the tendency of others to produce a focal infection—e.g., the staphylococci—is equally well known. The hemolytic streptococci and *Cl.* welchii produce fibrinolysin and other substances which favor resistance to phagocytosis, as well as breakdown of the tissue barriers that normally oppose the spread of infection. The staphylococci, on the other hand, produce coagulase and other substances, such as alpha toxin, which cause a dense, hard fibrinous zone to surround staphylococcal infections and assist in the survival and the growth of the organisms in the focus of infection.

During the early invasive phase, most bacteria responsible for acute infections are extracellular parasites which can be destroyed promptly when they are ingested by phagocytic cells. Specific antimicrobial action aids and abets phagocytic activity already initiated by the body. The chief purpose of specific therapy, therefore, is to arrest the spread of invasive infection and to suppress the proliferation of bacteria before extensive tissue necrosis has taken place, so that the patient may recover promptly, with minimal formation of scar tissue and with little likelihood of recurrence of infection. Elimination of the micro-organisms and the devitalized or dead tissues is prerequisite for wound healing. With staphylococcal infections, unless the body defense mechanisms are able to overcome the infection quickly, damage to the blood supply and the tissue results in necrosis and degeneration and liquefaction of the cells in the zone of inflammation in abscess formation. Surrounding the necrotic plug or abscess is a wall of inflammatory induration composed of edematous tissue cells, closely infiltrated with active leukocytes and walled off more or less completely from the surrounding tissues by fibrin strands interwoven between the normal cells. The rapidity with which this induration forms a wall round the locus of infection varies greatly with the type of invading organism. At this stage, leukocytes in the necrotic area are deprived of their optimal phagocytic activity.[16] Two reasons have been advanced for this: (1) the absence of normal tissue structures in the center of the abscess deprives the leukocytes of the surface upon which they operate most effectively; (2) leukocytes, when they are deprived of oxygen, quickly become nonmotile and lose their phagocytic properties. Since the only source of oxygen in a purulent focus is the intact capillaries at the periphery of the lesion, it is scarcely surprising that all bacteria in pus may

not be destroyed by natural mechanisms. Thus, if permitted to continue, the therapeutic effects of antibiotic therapy are, in the main, vitiated because (1) there is less free contact between the antibiotic and the lesion as it becomes more sequestered from the blood supply, and (2) the organisms may be less susceptible to antibiotic suppression because they are growing and multiplying more slowly in an environment unfavorable to antibiotic action. Once fluctuation is present, surgical drainage is usually indicated. Drainage of the pus reduces tension in the area of inflammation and relieves pain. Release of tissue tension enhances the likelihood of contact between blood-borne antibiotic and the micro-organisms, and restores more favorable conditions for phagocytosis and wound healing

The function of the surgeon treating acute infections is to favor or help the processes which the body has already initiated. From the foregoing we may deduce the principles of local treatment of inflammation due to infection which are designed to assist the body defense mechanisms. In the early or invasive stage, treatment consists of physiologic rest through immobilization, protection of the area from trauma by splints and dressings, and elevation of the area of inflammation whenever possible to reduce swelling and the institution of specific antibiotic therapy. To these are added incision and drainage when fluctuation and pus are present.

ANTIBIOTIC-PARASITE RELATIONSHIPS

When penicillin became available, it was hoped that the therapeutic problem of pyogenic surgical infections would be solved. Expectations were realized to a large extent for hemolytic streptococcal and many staphylococcal infections. It was soon found, however, that in certain conditions and circumstances, penicillin exerted little or no beneficial effects. The limitations include the following conditions:

1. When infection is due to gram-negative organisms, such as *Pseudomonas*, *Proteus* and coliform bacilli, and others shown in vitro to be unaffected by penicillin.

2. In about 10 per cent of staphylococcal infections encountered outside the hospital in which the organisms are resistant to penicillin; so far no resistant hemolytic streptococci of human origin and practically no resistant clostridia of the gas-gangrene group have been encountered.

3. In infections due to susceptible organisms treated late, in necrotic soft tissue or bone, and in the center of abscesses.

4. Against bacterial toxins, especially those of gas gangrene and tetanus

Other limitations were also recognized. Penicillin administration is followed by untoward reactions in some patients The bacterial flora of wounds which do not heal rapidly and the micro-organisms indigenous to the body, e g., the throat, may be replaced during penicillin therapy by different and resistant organisms. Other antibiotics have been introduced to fill these gaps, and undoubtedly the list is not yet complete as the search for new antibiotics goes on. Available to the surgeon at the present time, in addition to penicillin, are streptomycin, the tetracycline antibiotics (chlortetracycline [Aureomycin], oxytetracycline [Terramycin] and tetracycline), chloramphenicol, erythromycin, neomycin,

TUBERCLE BACILLI	GRAM-POSITIVE ORGANISMS	MENINGOCOCCI GONOCOCCI	GRAM-NEGATIVE BACILLI	RICKETTSIA LARGE VIRUSES

TYROTHRICIN
BACITRACIN
PENICILLIN
STREPTOMYCIN — NEOMYCIN
CHLORAMPHENICOL — TETRACYCLINES
POLYMYXIN
ERYTHROMYCIN

Fig. 78. Relative sensitivity of antibiotics to various groups of micro-organisms

bacitracin and polymyxin. Each has its advantages and its limitations.[10,15]

From the foregoing, two basic requirements for effective antibiotic action on micro-organisms in tissues can be derived: (1) the antibiotic must be capable of inhibiting the growth of the etiologic agent or agents causing the infection; (2) a therapeutically effective concentration of the drug must be in contact with the tissues in which the bacteria reside for a long enough period to allow the cellular defense mechanisms of the body the opportunity to eliminate them.

The choice of an effective antibiotic depends upon knowledge of both the identities of the microbial species involved and the relative effectiveness of the various antibiotics in suppressing them. The antimicrobial spectra of the major antibiotics for groups of organisms are shown in Figure 78. Various strains of bacteria within these groups exhibit variation in their susceptibility to the different antibiotics.

Current trends may be summarized as follows:[11]

Hemolytic streptococci of human origin (Group A), infection with which is usually manifested by cellulitis, lymphangitis, erysipelas or bacteremia, are uniformly[9] and highly susceptible to all the major antibiotics except streptomycin, neomycin and polymyxin.

About 75 per cent of the alpha streptococci which are not usually wound pathogens per se are sensitive to penicillin, and about 90 per cent are sensitive to the tetracycline antibiotics and chloramphenicol.

Most enterococci *(Streptococcus faecalis)* which alone or in combination may be encountered in urinary tract infections or intestinal fistulas are penicillin resistant; about 65 per cent are sensitive to the tetracycline antibiotics, chloramphenicol and the com-

bination of penicillin and streptomycin.

The pathogenic staphylococci, normally carried in the nose and on the skin of about half the population, and responsible for such lesions as paronychiae, furuncles and carbuncles, cellulitis, infected open wounds and osteomyelitis, are the only species of organisms originally predominantly sensitive to penicillin and the other antibiotics which have shown a pattern of increasing resistance to these antibiotics.

This phenomenon is related to the widespread use of antibiotics. Before penicillin became generally available, about 5 per cent of the staphylococci recovered from patients were found to be naturally resistant, at the present time the figure for the population at large has doubled or trebled. The situation in hospitals is much less fortunate, at the present time the majority of staphylococci of inpatients are found to be penicillin resistant, and of these over half are also streptomycin and tetracycline resistant. The combination of nasal carriage of resistant staphylococci by hospital personnel and of the presence of open wounds harboring these organisms forms the reservoir which contributes to perpetuation of the problem.

For these reasons it becomes necessary to make a distinction as to the empiric choice of antibiotic therapy for staphylococcal infections, depending on whether the patient developed the infection in the hospital or outside the hospital, and, to a certain degree, on whether he did or did not receive antibiotic therapy within the period of, say, 3 months prior to onset of the present illness. In the nonhospitalized patient who has not received penicillin before, or in recent months, the chances are about 6 out of 7 that the staphylococci causing the infection are susceptible to penicillin. The odd penicillin-resistant staphylococcal infection is likely to harbor micro-organisms which are susceptible to the tetracycline antibiotics, chloramphenicol or erythromycin For infections arising in the hospital, chloramphenicol, erythromycin and bacitracin are likely to be effective.

Actinomyces israeli (actinomycosis), many of the spirochetes (Vincent's angina, syphilis) and the pathogenic clostridia (gas gangrene) are predominantly sensitive to penicillin, the tetracycline antibiotics and chloramphenicol.

The gram-negative enteric bacilli usually incite a purulent reaction with tissue necrosis in previously traumatized or diseased tissues; they are also commonly the cause of urinary tract infection. In wounds, their ill effects are three: (1) they form a potential medium for the gram-positive invasive coccal organisms; (2) they may delay wound healing; (3) on occasions, as in thermal burns or following instrumentation of the urinary tract, they may invade the bloodstream and a septicemia results. Ordinarily, they produce few ill effects and disappear with the institution of free drainage and elimination of devitalized tissues and dead space. Except for septicemia and simple urinary tract infection, antibiotic therapy plays a secondary role to indicated surgical procedures.

An important contributory factor is that no single chemotherapeutic agent is effective against all species or against all strains within a given species. At present, about 80 per cent of *Escherichia coli* and 60 per cent of *Aerobacter aerogenes* strains are susceptible to streptomycin and the "broad-spectrum" antibiotics. However, only 50 per cent of *Proteus* spe-

cies are sensitive to streptomycin, chloramphenicol or neomycin, and only occasionally to the tetracycline antibiotics. For this reason, combination therapy, e.g., with streptomycin and chloramphenicol, may be indicated in *Proteus* infections. High concentrations of penicillin are also inhibitory for certain strains of *Proteus*.[13] Practically all *Ps. aeruginosa* strains are susceptible to polymyxin, while only a small percentage of them is sensitive to streptomycin and the broad-spectrum drugs. Thus, culture sensitivity may be necessary to guide the choice of drug to be used. Because of the possibility of emergence of drug-resistant strains before the infection is completely eradicated, streptomycin has been superseded by one of the "broad-spectrum" antibiotics When it is employed, it is usually in combination with another antimicrobial drug of similar antimicrobial spectrum.

Another factor which bears on the selection of an antibiotic for therapy is that antibiotics with presumably similar mechanisms of action may cause the emergence of resistant forms to each other (cross resistance).[2,4,15] Thus, micro-organisms resistant to one tetracycline antibiotic are usually resistant to the other two, and they may or may not be simultaneously resistant to chloramphenicol; and staphylococci resistant to erythromycin are also resistant to carbomycin. Finally, open lesions which are slow in responding to treatment may become infected with a new species of organisms refractory to the drug being employed (superinfection).

From all the foregoing, it is obvious that rapid identification of the etiologic organisms by gram stain of the direct smear (a simple and too often neglected method which often sustains or helps to make a clinical diagnosis and will indicate that material should be started for culture) and culture and antibiotic sensitivity tests are the true criterion for selection of antibiotics for therapy and are preferable to blind selection of an antibacterial agent during the first few days of treatment.

From a practical point of view, this generalization may be modified somewhat In private practice, as well as in the hospital, decisions concerning initiation or change of antibiotic therapy have to be made when culture sensitivity data are not, or are not yet, available. From the foregoing, certain guides to the choice of antibiotics may be deduced:

Penicillin is the drug of choice in all hemolytic streptococcal surgical infections and in fusospirochetal, anthracic and actinomycotic infections. This choice may have to be tempered by clinical considerations, including those concerning allergic reactivity and other undesirable side effects, the history of previous treatment with antibiotics and any circumstance suggesting the presence of resistant organisms. In these circumstances the surgeon can turn to the "broad-spectrum" antibiotics, which are also effective.

Penicillin is the empiric agent of choice in acute staphylococcal infections developing outside the hospital environment If there is no favorable response in 48 hours, the statistical data indicate that erythromycin, chloramphenicol and one of the tetracycline antibiotics may be effective. For the treatment of lesions accessible to local therapy, bacitracin and neomycin merit consideration.

Mixed infections may be treated empirically by a combination of penicillin and streptomycin, or chloram-

Doses of Antibiotics Usually Employed

Antibiotic	Route	Preparation and Dose	Interval
Penicillin:			
Very responsive infections	I. M.	Aqueous solutions, 300,000 u.	8–12 hours
	I. M.	Penicillin esters* 300,000–600,000 u.	24 hours
	Oral	Tablets 500,000 u.	8 hours
Less responsive infections	I. M.	Penicillin esters* 600,000–1,200,000 u (2 to 4 cc.)	6–12 hours
	I. M.	Aqueous solutions, 1–2 million u.	4–6 hours
	I. V.	Aqueous solutions, ½–40 million u. per day	Continuous infusion
Streptomycin or dihydrostreptomycin:			
Infections other than tuberculous	I. M. (adults)	0.5 Gm.	8–12 hours
	I. M. (children)	12.5 mg./Kg.	6 hours
Tuberculosis	I. M. (adults)	1 Gm.	24–72 hours
	I. M. (children)	15–25 mg./Kg.	24–72 hours
The Tetracyclines	Oral (adults)	0.25–0.5 Gm.	6 hours
	Oral (children)	25 mg./Kg. 50 mg /Kg./day	Initially 6 hours
	I. M.	100 mg.	6–12 hours
	I. V.	7–14 mg./Kg.	12 hours
	Topical	5–30 mg./Gm	
Chloramphenicol	Oral (adults)	2–3 Gm. 0.5–1.0 Gm.	Initially 6–8 hours
	Oral (children)	50 mg./Kg./day 100 mg./Kg./day	Initially 6 hours
	I. M	100 mg	6–12 hours
	I. V.	0.5 Gm	6 hours
	Topical	5–30 mg./Gm.	
Erythromycin	Oral	200–400 mg.	4–6 hours
	Topical	5 mg./Gm.	

*Procaine penicillin, Benzathine penicillin (Bicillin).

Doses of Antibiotics Usually Employed (*Continued*)

Antibiotic	Route	Preparation and Dose	Interval
Bacitracin	I.M.*	10,000-50,000 u.	6 hours (Max. doses 100,000 u.)
	Topical	500 u./Gm.	
Polymyxin	I.M.*	2.5 mg./Kg./day	6 hours
	Topical	0.1 per cent	
Neomycin	Topical	5 mg./Gm. or ml.	

*Used primarily in hospitals

phenicol or the tetracycline antibiotics. Polymyxin is the only drug to which the majority of *Pseudomonas* organisms are susceptible, while no single agent is uniformly effective against *Proteus* infection.

The best insurance against disappointment is to investigate the nature of the infecting agent whenever possible, to do so early, and, if the situation warrants, to do so repeatedly.

In acute infections with accessible open lesions, immediate examination by gram-stain smear and culture sensitivity tests of exudate obtained by incision and drainage or aspiration with needle and syringe from the actual site of the infection is recommended to help establish the clinical diagnosis and the nature of the infecting agent. In this way, a mistaken choice of antibiotic can be corrected within 24 to 48 hours on the basis of culture sensitivity tests.

Precise bacteriologic diagnosis, which implies culture sensitivity testing, in addition to a clinical-anatomic diagnosis, is essential for optimal success of antibiotic therapy in (1) draining lesions not responding to a 48-to-72-hour trial of initial empiric therapy, (2) recurrent or metastasizing infections and (3) chronic infections in which the surgeon cannot tell exactly on inspection the etiologic nature of the infection which he must treat. If the lesion is open and liable to superinfection, e.g., a thermal burn, it is advisable to repeat culture sensitivity tests at five-day intervals to guide continued antibiotic therapy. In the instance of mixed infection, the results guide the choice of combination therapy if it is indicated.

ANTIBIOTIC-HOST INTERACTIONS

The molecules of drug which arrive in active form from the bloodstream at the site of an infection represent a small fraction of the much larger numbers which were present in the administered dose. Much of the absorbed antibiotic, when in contact with body fluids, is rendered inactive by binding. Adequacy of the blood

supply and the stage of the infection further determine the effective concentration of active drug in contact with the micro-organisms. In general, therapeutic concentrations of antibiotic obtain in living tissues with a good blood supply after parenteral administration, whereas lower or inadequate concentrations obtain in necrotic tissue and large collections of pus, and in contaminated blood clots and hematomas (which are comparable with masses of dead tissue). Persistence of blood-borne antibiotic at the locus of infection is dependent on the duration of effective blood levels following the administration of a given dose.

The usual doses of antibiotics for surgical infections are summarized in the foregoing table. Some amplification is in order, in view of the confusion which sometimes arises from the variety and the multiplicity of dosage forms available. The problem with penicillin therapy is whether the aqueous or the repository form of drug is the one of choice. In hemolytic streptococcal infections, which are quite susceptible to penicillin, the aqueous suspension of procaine penicillin, 300,000 units given intramuscularly at intervals of from 12 to 24 hours, is very effective In staphylococcal and in mixed infections, aqueous penicillin, 600,000 units or more given intramuscularly at 6-hour intervals, is best but impractical for use on outpatients. Three hundred thousand units of aqueous penicillin in solution used to suspend 300,000 units of procaine penicillin, given intramuscularly every 12 to 24 hours, may also be effective. Oral penicillin is reserved for the treatment of hemolytic streptococcal infections in children, because, in adults at least, it is no more effective than 30 per cent of the same dose given intramuscularly.

When streptomycin is used for nontuberculous infections, the usual dosage is from 1.0 to 2.0 Gm. daily by the intramuscular route for no longer than 5 to 7 days. It is now rarely regarded as an effective drug singly because of the well-known potentiality for emergence of drug-resistant strains during therapy, for which reason streptomycin is usually given in combination with penicillin, erythromycin or the tetracycline antibiotics for the purpose of increasing the effectiveness or the antibacterial spectrum. Tuberculosis is treated with a combination of streptomycin and the other tuberculostatic drugs.

The tetracycline antibiotics, which are closely similar in their action in vitro and in vivo, are indicated principally in infections resistant to penicillin and in those occurring in patients who cannot tolerate penicillin or prefer oral therapy. Following a loading dose of 1.0 Gm., the usual dosage for adults is 0.5 Gm. every 8 hours. Chloramphenicol overlaps the range of infections favorably influenced by the tetracyclines, except that strains of staphylococci resistant to penicillin and the tetracyclines are usually susceptible to chloramphenicol; also, it is somewhat more effective against *Proteus* and *Pseudomonas* organisms. The intramuscular and the intravenous forms of these broad-spectrum antibiotics are indicated principally among hospitalized patients in whom, for one reason or another, the oral route is barred.

Erythromycin closely resembles penicillin in its antibacterial activity. Its major indication is in the treatment of staphylococcal infections resistant to penicillin and the broad-spectrum antibiotics and in patients who exhibit unfoward reactions to the latter

drugs. The doses recommended for adults are from 200 to 400 mg by mouth every 4 to 6 hours.

Bacitracin, polymyxin and neomycin are used singly or in combination for topical therapy. Parenteral therapy with polymyxin or bacitracin is reserved primarily for indicated severe infections treated in the hospital. Ordinarily, optimum therapeutic results can be achieved in the majority of surgical infections by selecting the most active single antibiotic. The widespread practice of employing two, or even more, antibiotics at the same time is inexcusable in most instances.

Local Therapy

There are two broad categories of cases in which local treatment is employed: (1) against lesions to which the drug is not likely to gain access in therapeutic concentrations when it reaches the bloodstream following parenteral administration—e.g., in affections of joints or in fibrotic or otherwise poorly vascularized regions of the body; and (2) where systemic therapy is undesirable—e.g., in minor open infections of the soft tissues, abscess cavities and large dead spaces. Local therapy has as its objective the achievement of high concentrations of antibiotic at the site of accessible lesions that are refractory to systemic chemotherapy. Even though a high concentration of antibiotic is applied to the lesion, it does not necessarily follow that resolution of the infection will occur. On the contrary, there is evidence which suggests that the activity of certain drugs is reduced or abolished by factors which obtain in necrotic foci. The principal considerations which apply in the use of antibiotics locally are as follows:

Factors in the Wound Which Are Detrimental to Antibiotic Activity. These factors include unfavorable pH, biologic materials which inactivate the antibiotic (e.g., albumin, phospholipids, enzymes such as penicillinases), low metabolic turnover of the organisms ("resting" cells) which makes them inert to any but "bactericidal drugs," and loculation or intracellular location which protects the bacteria from the antibiotic. (Bacitracin, neomycin and polymyxin may be bactericidal in vivo.) As a result, unless these unfavorable environmental conditions are corrected by adequate surgery, in addition to the local application of the antibiotic, the therapeutic response is likely to be disappointing. The requisites for succesful topical therapy therefore are (1) the absence of necrotic tissue, (2) adequate constant contact between the site of infection and the antibiotic and (3) prevention of reinfection of the lesion by a rigid aseptic technic of wound management.

Allergenic Potentialities. Penicillin and streptomycin are potential sensitizing agents when applied to skin and mucous membranes. For this reason, they are now less widely used than the potentially less allergenic bacitracin, erythromycin, neomycin, polymyxin and the broad-spectrum antibiotics.

Degree of Local Irritation and Tissue Toxicity. Tissue-culture studies indicate that penicillin, neomycin and bacitracin are essentially nontoxic for human fibroblasts and epithelial cells in the concentrations ordinarily employed for topical use.[6] The other antibiotics, when tested in a similar manner, are represented in order of increasing toxicity as follows: chloramphenicol, the tetracyclines, polymyxin, gramicidin.

Toxic Reactions[7]

All currently approved antibiotics are capable of producing toxic reactions in some patients. Hypersensitivity reactions, manifested by local inflammatory reactions at the sites of injections, and various types of skin eruptions or lesions, with or without swollen joints, may occur when penicillin, streptomycin or dihydrostreptomycin is administered to a sensitive patient. Contact dermatitis due to these antibiotics may occur in those who handle them frequently or have them applied often to the skin. Drug fever is another type of reaction common to penicillin and streptomycin. Vertigo, tinnitus, disturbances in equilibrium and deafness, due to eighth nerve injury, are other well-known complications in therapy with streptomycin and dihydrostreptomycin. Streptomycin may also produce renal difficulties, particularly in patients with underlying renal disease.

The intramuscular administration of concentrated solutions of some of these drugs may result in the introduction of the drug into a peripheral nerve and give rise to a chemical injury, producing motor and sensory changes that may persist for a long time. Paresthesias of the hands, the tongue and the circumoral areas may follow the parenteral administration of polymyxin; these phenomena disappear on cessation of therapy with the drug. Polymyxin, bacitracin and neomycin have a potential primary toxicity for the kidney which is completely reversible if the damage has not progressed too far. For this reason, a dosage ceiling has been imposed on their use parenterally, and they are reserved for intramuscular use in serious types of infections in which other less toxic chemotherapeutic agents have failed.

Renal injury from the use of the broad-spectrum drugs has not been reported.

Oral lesions, ulcerative or vesicular stomatitis and glossitis, have followed the administration by mouth of penicillin, chloramphenicol and the tetracyclines. Disturbances of the gastrointestinal tract also result from the oral administration of the tetracycline antibiotics, particularly if the daily dosage exceeds 2 Gm. These include nausea and vomiting, and, more seriously, diarrheas with liquid stools containing large amounts of mucus and pus which may be of sufficient severity to result in dehydration and prostration. Some of these diarrheas may represent cases of acute *Staph. aureus* enteritis, resulting from the change in the bacterial flora of the bowel produced by these agents. These are usually alleviated promptly by the cessation of the drug. Acute colitis, either ulcerative or membranous, in which the intestinal flora consists predominantly of either *Staph. aureus* or strains of *Pseudomonas* and *Proteus*, has been reported, although this reaction has been rare. The liver may also be affected in patients treated with chlortetracycline and oxytetracycline; fatty changes in the liver cells after biopsy have been noted.

The significance of these findings needs to be defined. Vitamin deficiencies, particularly those of the B complex, have been described. Changes in the peripheral blood or the blood-forming organs have been reported only during the use of chloramphenicol

Superinfection[14]

During antibiotic therapy, suppression of susceptible micro-organisms

is not restricted to the lesion for which it is given. Organisms sensitive to the antibiotic which reside in other areas of the body heavily populated with bacteria are also held in check, permitting an abnormal proliferation of drug resistant forms. The species that have been observed to increase most frequently during chemotherapy are *P. vulgaris, Ps. aeruginosa* (pyocyaneus), *Staph. aureus* and the fungi and yeasts.

While this phenomenon may occur with any antibiotic, it is most common after administration of one of the broad-spectrum drugs, especially when excessive doses are being used. While this by-product of antibiotic is frequently of no consequence, or no more annoying than a mild pharyngitis, stomatitis, proctitis or vaginitis, on occasions it may be responsible for superimposition of a serious infection on the one for which treatment was instituted initially. It should be watched for in patients in whom the body defenses are impoverished—e.g., those with blood dyscrasias, diabetes, advanced liver diseases, nutritional deficiencies or neoplastic disease. The very young are also prone to develop superinfection. It is manifested most frequently on the fourth or the fifth day after initiation of antibiotic therapy.

These phenomena emphasize once again the danger of antibiotic therapy in lesions that are treatable or self-limiting, since superinfection may be a serious threat. It emphasizes also the need for critical appraisal as to whether antibiotic therapy is actually necessary after 5 days. When superinfection occurs and is serious, discontinuance of the antibiotic is almost a necessity. If the symptoms are mild, there is seldom any difficulty in reversing the process; otherwise, culture-sensitivity testing should guide additional specific chemotherapy.

PRINCIPLES OF TREATMENT OF INFLAMMATION DUE TO INFECTION

Experience has shown that the results obtained with modern antimicrobial agents in the adjunctive treatment of inflammations due to infection depend largely upon the clinician's application of certain well-established surgical principles. When used properly, the antibiotics can influence profoundly the prevention and the control of surgical infections. When used improperly, the clinical results may be limited, incomplete or absent. Of necessity, the application of principles must vary with the type and the location of the infection, but, in general, some or all of them may be applied with benefit in every case.

Early Diagnosis

Early diagnosis is of considerable importance in determining the results obtained in antimicrobial therapy in regard to morbidity, functional results and even mortality. If the diagnosis is established early, when pure or single bacterial infections are in the diffuse or the cellulitic phase, antibiotic therapy is apt to produce a prompt and rapid reversal of the invasiveness and its toxic effects, with complete and spontaneous resolution or a minimal amount of tissue destruction or other complications. If therapy is instituted later, after local necrosis or abscess formation has occurred, the effects are more limited and delayed. Frequently, chemotherapy will so control the invasive qualities of certain infections that emergency radical surgical decompression

or excision of infected areas either becomes unnecessary or can be replaced by more conservative local types of surgery done at a time when the condition of the patient is improved.

Accurate Diagnosis

Surgical inflammations may be due to a single type of organism, or they may be mixed. They may be primary or secondary.

A primary lesion is defined as one in which there is no apparent pre-existing derangement—e.g., lymphangitis or carbuncle. Primary lesions are often due to a single species of organism, such as the hemolytic streptococci or the staphylococci.

Secondary infections are those superimposed on such pre-existing conditions as trauma, dermatitis, neoplasm or circulatory deficiency. Incomplete response to antimicrobial therapy may stem from failure to diagnose and treat concomitantly the underlying and abetting pathology. It must be stressed that the presence of bacteria in open lesions does not necessarily exclude the presence of an underlying process other than infection. Not infrequently, staphylococcal, streptococcal or other organisms are isolated from lesions which have as their underlying basis fungal infection, tuberculosis, neoplasm or other lesions. The earlier and more complete the diagnosis, therefore, the more likely the prospects for a favorable outcome.

Selection of the Appropriate Antibiotic

This important aspect of therapy has already been discussed (p. 107).

The dosage of the antibiotic selected should be adequate to produce the desired antibacterial effects in the blood and in the extracellular fluids. The duration of therapy should be sufficiently long to permit the natural defense mechanisms of the body to eliminate the inhibited organisms in the lesion; on the other hand, unnecessarily prolonged therapy is unwise and may be harmful. As previously mentioned, after 72 hours the antibiotic therapy program should be reviewed, re-evaluated and changed as indicated.

Supportive Therapy

Systemic Measures

In addition to the antibiotic program already outlined in the treatment of infections in ambulatory patients, due consideration must be given to various systemic measures which have as their purpose an increase or the maintenance of the patient's general resistance. One measure in this regard is systemic rest, or at least the avoidance of fatigue. A balanced diet of easily assimilable foods and care to avoid constipation are valuable aids. When pain is not controlled by other means, acetylsalicylic acid or codeine may be administered in sufficient quantities to keep the patient comfortable until the wound becomes painless. The reduction of resistance to infection in diabetic and cachectic subjects and in others with an impoverished peripheral circulation is well known, and such conditions must be treated concomitantly with the infection. Patients with anemia or reduced blood volume may be benefited immeasurably by blood transfusions. The popularity of vaccines, toxoids and other biologicals (except for tetanus prophylaxis) for the purpose of increasing the pa-

tient's resistance or response to infection has waned since the widespread use of antibiotics

Local Measures

Elevation. Elevation as a therapeutic measure may be carried out readily when the infection is in one of the extremities; it is less easy when the infection is in other parts of the body. To be effective, the infected area should be above the level of the heart, so that in treating inflammations of the extremity the patient must lie down. However, a marked degree of swelling may be prevented, and venous and lymphatic drainage aided, by making sure that the part is not dependent: thus, to sit with a leg on a chair or to carry an arm or a hand in a sling is better than to put the leg on the floor or permit the hand to hang at the side. As a rule, because of the marked relief of pain, patients are quite willing to undergo the restraint which elevation may place upon their activities.

Immobilization. For the lesions which are treated in ambulatory patients, physiologic rest demands, in most cases, some degree of immobilization of the part. The extremities are best immobilized by the use of splints or bandages, slings and adhesive strappings. The methods of effecting immobilization will be discussed in the chapters on regional surgery. However, some mention must be made here of the protection of inflammatory lesions from external trauma. The most common type of trauma is the pinching and squeezing of local infections by the patient or by the energetic physician. There is no better way of breaking down the protective wall of induration and of producing an extension of the inflammatory process, and it is mentioned only to be condemned. Other forms of trauma, such as bumping or striking an area of infection, have the same result, hence the necessity for protection of the area with dressings and splints.

Application of Heat. Heat in any form when applied locally to an area of the body surface causes an increased rate of blood flow that is due to vasodilatation. This results in a rise in capillary pressure associated with an increased rate of transfer of fluid from the blood to the tissues, accelerated metabolic activity and an increase in phagocytosis. The greatest rise in temperature occurs at the point of contact, where the energy exchange is greatest. After a sufficiently long period of contact with the heat locally, deeper structures, as the result of conduction, also show a temperature rise. Excessive local temperature is prevented by the distribution of heat throughout the body by increased blood flow.

Prior to the availability and the use of specific chemotherapeutic agents for the treatment of inflammations, the use of either dry or moist heat was routine adjunctive treatment in the therapeutic regimen. Its use afforded relief of pain and spasm and favored drainage. Since antibiotics are now employed regularly in the management of infections, the application of heat, particularly in the form of hot soaks or hypertonic solutions, has given way largely to dry treatment. The principal indication for moist heat at the present is the open infection in which moist heat helps to loosen crusts and tissue debris and so favors drainage. Sodium chloride (2 teaspoonfuls salt to 1 quart of water) or magnesium sulfate (from 4 to 5 heaping tablespoonfuls to 1 quart of

water) in a physiologic or a slightly hypertonic solution is employed. Warm solutions applied to an open wound must be sterile.

In ambulatory patients, the chosen solution is sterilized by boiling for 10 minutes The sterility is maintained by applying the solution with a previously boiled glass syringe with a rubber bulb. The temperature of the solution should not exceed 110°F.; i.e., it should be cooled until it can be tolerated comfortably by the skin on the inner side of the elbow. The solution may then be applied to the entire dressing with a syringe, or the dressing may contain several small rubber tubes, through which the warm solution may be introduced Moisture and heat, if continued for more than 24 hours, predispose to increased swelling, the tendency to narrowing drainage exits by sodden tissues, and the prospects of satellite infection and superinfection.

The electric pad, if well protected

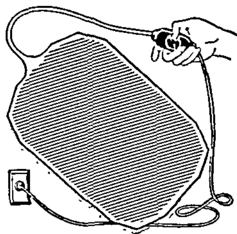


Fig. 79 Electric heating pad with complete rubber insulation This type of pad is excellent for maintaining a constant heat when wet dressings are being applied.

from wetting by wax paper, oiled silk or a rubberized cover, is probably the most effective method of applying heat for long periods of time. Care must be taken that the pad does not become wet, since a short circuit and burning may occur. Rubber cases are available for some pads, and there are others made with the heating unit enclosed in rubber (Fig. 79).

There are other precautions which must be considered in the use of heat. Extreme care must be exercised to avoid producing a troublesome burn, particularly in very young children, in old people, in patients who are debilitated, in those who are suffering from chronic disease, such as arteriosclerosis or other forms of impaired peripheral circulation, in those who have areas of malignant degeneration or suffer from hemorrhagic disease or sensory abnormality or impairment due to central or peripheral lesions of the central nervous system.

Timed Surgical Intervention. The nature of the lesion and the character of its response to treatment determine the need for surgical intervention. The extraordinary efficacy of antibiotic therapy in such hemolytic streptococcal lesions as cellulitis and lymphadenitis is evidenced by rapid control and resolution of the infection. Surgical intervention is necessary only in the case treated late in which localized abscess and/or gangrene has occurred. As a general rule, drainage is required in most fluctuant staphylococcal lesions, in order to limit further breakdown of the affected tissues, to reduce tension in the area of inflammation, to relieve pain, to provide ingress of blood-borne antibiotics and phagocytes, and to allow wound healing. The removal of sutures and the reopening of infected incisional

wounds and the removal of foreign bodies, infected necrotic tissue and sequestra are important for the same reasons. Occasionally it is possible to avoid extensive incisions and drainage of accessible small collections of pus by means of aspiration, followed by injection into the focus of bactericidal solutions of an antibiotic, as in furuncles and carbuncles. However, while effective chemotherapy has resulted in a marked reduction in the number of cases requiring extensive drainage for resolution, incision and drainage are still indicated when (1) the infection has localized and fluctuation is evident, (2) there is no likelihood of spontaneous rupture with adequate drainage, and (3) there is no danger of extension of infection as a result of surgical trauma. Continued drainage may be provided by various means. Rubber dam and tube drains are most commonly employed.

Prevention of Secondary Infection. In the treatment of an open infection, the danger of introducing secondary infection can be reduced to a minimum by the application of strict asepsis in the care and the dressing of the wound. Masking, sterile rubber gloves and an all-instrument technic should be employed. In any open infection, the first requisite is macroscopic cleanliness. The wound itself should be cleaned of liquid pus and necrotic tissue. The surrounding area should be kept free of pus and crusts, and should be protected from excoriation due to irritating discharges.

The surface of the wound is covered lightly with fine dry mesh gauze, such as sterile roller bandage gauze, over which compression dressings are applied. An absorbent dressing permits early and rapid removal of the liquefied wound secretions, and thus pro-



FIG. 80. Usual reasons for re-dressing wounds. (Pulaski, E. J.: S. Clin. North America, p. 1268, October, 1953)

motes a continued flow of serum, lymph and leukocytes into the wound. It should be bulky enough to avoid soaking through. Constrictive circular bandages are avoided. Elastic cotton bandages are useful, but care must be exercised in applying them, for they, too, may cause constriction if they are too tight. Dressings are changed only as necessary, since too frequent changing enhances the possibilities of contamination and increases exudations. Since bacteria from the external environment readily penetrate moist gauze, open wounds should have waterproofed external dressings. The usual reasons for re-dressing wounds are given in Figure 80.

PROPHYLAXIS WITH CHEMOTHERAPEUTIC AGENTS

One of the most excessive uses of antibiotics is for prophylaxis against infection. While it may seem vain to state that the prevention of wound infection is a surgical exercise and that

water) in a physiologic or a slightly hypertonic solution is employed. Warm solutions applied to an open wound must be sterile.

In ambulatory patients, the chosen solution is sterilized by boiling for 10 minutes. The sterility is maintained by applying the solution with a previously boiled glass syringe with a rubber bulb. The temperature of the solution should not exceed 110° F.; i.e., it should be cooled until it can be tolerated comfortably by the skin on the inner side of the elbow. The solution may then be applied to the entire dressing with a syringe, or the dressing may contain several small rubber tubes, through which the warm solution may be introduced. Moisture and heat, if continued for more than 24 hours, predispose to increased swelling, the tendency to narrowing drainage exits by sodden tissues, and the prospects of satellite infection and superinfection.

The electric pad, if well protected

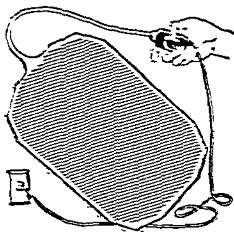


Fig. 78. Electric heating pad with complete rubber insulation. This type of pad is excellent for maintaining a constant heat when wet dressings are being applied.

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the protection afforded by chemotherapy is limited in scope, this fact must be re-emphasized because of the sensitization reactions and other untoward effects attending antibiotic usage. There is no evidence that antibiotics are of value or are indicated in elective clean surgical procedures. Nor is there any evidence that their use need be continued beyond 2 or 3 days in competently managed contaminated wounds. Finally, there is no evidence that antibiotics can be substituted for antitetanus therapy in the patient who is or is not sensitive to tetanus antiserum. The dosage for prophylactic antibiotic therapy is approximately the same as that employed for the treatment of acute hemolytic streptococcal infection.

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Specific Surgical Lesions

EDWIN J. PULASKI, LIEUTENANT COLONEL, MC, USA

FOLLICULITIS, FURUNCLES AND CARBUNCLES[1-16]

Stages of Infection. Folliculitis, furuncles and carbuncles are the names applied to local staphylococcal infections of the skin and the subcutaneous tissues. As a rule, they begin as an infection of a hair follicle or of a sebaceous gland and progress to produce a small area of induration with central necrosis known as a pimple or a pustule. Further extension involves underlying subcutaneous tissues, forming a single area of central necrosis surrounded by a well-formed area of redness and induration which is called a furuncle or a boil (Fig. 81). In areas in which there are dense fibrous septa extending from the skin to the underlying fascia, as in the back of the neck, the infection may extend from one area of subcutaneous tissue to another without effective walling-off of the process, thus attaining a considerable size. This lesion is known as a carbuncle. It may be noted, therefore, that these lesions must be looked upon as progressive stages of the same process, and the variations in progress may be considered, in part, as index of the patient's general and local "resistance" to the staphylococcal infection and of the architecture of the infected tissues.

Predisposing Factors. In many instances the recognition and the appropriate management of the predisposing factors may be as important as the administration of specific measures. Therefore, it is essential to keep in mind the following recognizable local and systemic factors which determine the degree of "resistance" of the skin to pyogenic infection: (1) trauma of any form, which includes exposure to irritants, deodorants and defatting agents; (2) poor hygiene; (3) local causes of pruritus, such as insect bites and pediculosis capitis; (4) excessive sweating, especially of intertriginous sites, hands and feet; climatic factors; (5) foci of infection; (6) diabetes and (7) blood dyscrasias. It has been emphasized in Chapter 7 that it is essential for the physician to recognize and correct these predisposing factors whenever they are present in order to effect complete and permanent disappearance of the infection.

Location and Description. These lesions may occur on any part of the body, but the most frequent sites are the face, the back of the neck, the axillae and the groins, the buttocks, the arms and the proximal phalanges of the fingers.

The earliest lesion is characterized by a small reddened firm mound of induration which is itchy and tender and in a few days shows a central yellow point. This furuncle, or



FIG. 81. Photomicrograph of furuncle or boil.

pimple, may extend no farther, and the process may subside with the discharge of a drop or two of pus. Frequently, however, there is a deeper extension with gradual enlargement of the area of inflammatory induration. Pain, which is a common manifestation, is present, and it increases with motion. In this case the area of inflammation has extended beyond the skin into the subcutaneous tissues, and the protective wall of inflammatory induration usually takes from 4 to 6 days to become well formed if untreated. By this time the central necrotic core, with serosanguineous pus, is prominent, and drainage of pus and slough may occur spontaneously or after surgical incision. As soon as drainage is established, tension is relieved, pain decreases in severity, and the process subsides when the necrotic cavity has been evacuated completely.

In the carbuncular type of infection, most often seen in the back of the neck or on the dorsum of the hand, the walling-off process does not seem to keep pace with the tendency of the infection to spread in the poorly resistant fat lobules lying between the fibrous tissue septa beneath the skin. As a result, the inflammatory wall of induration is frequently wide in diameter, and pointing takes place at multiple areas in the skin follicles over the underlying central necrosis. In such cases, the deficiency of the walling-off process is indicated by the elevated temperature and evident "toxemia" as a result of absorption from the area of infection. In most cases, however, central necrosis and liquefaction, combined with an overlying destruction of the skin, will permit evacuation of the tissues. Eventually, liquefaction necrosis of the fibrous septa results in complete drainage of the necrotic tissue from the abscess cavity.

The prognosis depends on the clinical type of infection, the site of involvement, the predisposing factors, the duration and the nature of the causative organisms. Superficial pustular folliculitis and furuncles tend to have a more or less self-limited course and to clear up readily with various types of therapy. In some cases furuncles are recurrent. A dominant etiologic factor may be an underlying dermatitis, in which case proper treatment may result in a permanent cure of the condition. Because they are auto-inoculable, staphylococci may be carried from a lesion and infect other parts of the body. Unless suitable precautions are taken, the micro-organisms are conveyed, by fingers or handkerchief, to other parts of the body, such as the nose, the eyes and the external ear, where they are liable to persist. Recurrent infection in the axilla, a warm, moist, hairy area, with apocrine glands, is readily understandable. All physicians recognize that furuncles and carbuncles in the center of the

face may give off small emboli and give rise to cavernous sinus thrombosis, septicemia or metastatic infection at some distance away from the original infection. Also, it is well known that the staphylococcal infections in the newborn and in children may lead to serious sequelae, such as osteomyelitis. Appropriate antibiotic therapy has reduced the mortality and the morbidity from these serious complications of cutaneous infections to a significant degree.

In general, cutaneous pyogenic infections of brief duration are more amenable to therapy than those which are chronic. The causative organism also influences the prognosis. If the offending *Staphylococcus aureus* is sensitive to the antibiotic selected, institution of adequate effective therapy as quickly as possible after the infection becomes apparent is likely to result in prompt resolution of the infections.

Conservative Therapy. The treatment of established local staphylococcal infections still rests chiefly on the surgical principles of rest, elevation and heat, and drainage when pus has formed. Scrupulous cleanliness, attained by the liberal use of soap containing a mild antiseptic such as hexachlorophene and water, is the first principle of management. Contiguous areas likely to be attacked are shaved. In such areas as the groins, the axillae, the gluteal cleft and the inframammary region, fine dusting powder may be used to reduce maceration of the skin. Deodorants, which occlude the pores, are avoided. For the smaller furuncles and carbuncles, effective treatment further consists in protection and immobilization of the area with a fine mesh gauze dry dressing over an application of bacitracin or neomycin ointment, held in place by small dabs of liquid adhesive or cellophane glued (Scotch) tape. In many cases, the infection may be aborted by this treatment; in others, the use of 95 per cent phenol, cautiously applied with a toothpick swab to enlarge a small sinus or to open an abscess near the surface which is pointing, is still good practice. After two or three days, the area of central necrosis may be lifted out with a sterile forceps or mosquito hemostat. This treatment is continued until all the central slough has liquefied and drained away.

In some boils, when movement of a part prevents an effective walling-off of the process and when there is an associated cellulitis of the adjacent tissues, as, for instance, in furuncles on the face or on the dorsum of the proximal phalanx of the finger, the application of splints and dry heat is beneficial. Parenterally administered penicillin or one of the other antistaphylococcal antibiotics is given to hasten localization of the infectious process. Under this regimen the cellulitis surrounding the lesion will subside in 36 to 48 hours, and, with localization of the process, there will be a discharge of the central necrotic area followed by rapid healing. Incision in such cases is not performed until localization has taken place, and by this time spontaneous drainage will begin.

The many forms of treatment which have been devised for carbuncles are an indication of the inability, before the availability of antibiotics, to control the locally or generally invasive characteristics of this infection. The majority of surgeons had learned to employ crucial incisions or excision, and, because of the tendency of carbuncles to extend locally or to invade the general circulation, radical exci-

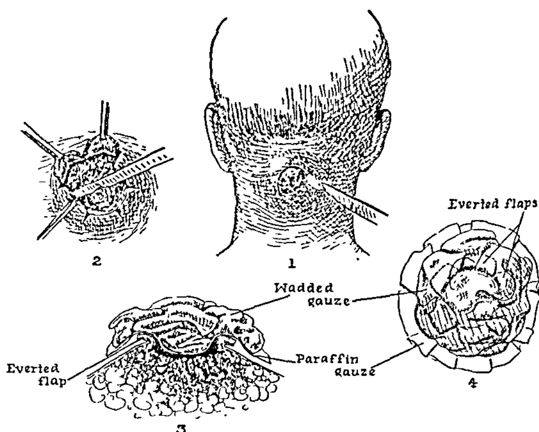


Fig 82 Treatment of carbuncle. (1) Excision of central necrotic core. (2) Radial incision and undercutting of flaps to expose the base of the carbuncle (3 and 4) After excision of necrotic tissue the wound crater is overlaid with a sheet of paraffin gauze and packed with wadded fluffed gauze This method of treatment is used rarely now, except in neglected cases See text

sion was commonly practiced (Fig 82).

The use of penicillin and the other antibiotics has revolutionized the treatment of this condition When they are administered early and in sufficient dosage, they aid the body defenses in bringing under control the general and the local manifestations within a period of 48 to 72 hours, and they have so modified the subsequent course that both mortality and morbidity are reduced significantly.

Complete and spontaneous resolution may be expected in about 40 per cent of the cases, and partial resolution with necrosis or abscess formation in the remaining 60 per cent.

Since the invasive qualities of this lesion now are so effectively controlled by antibiotics, radical excision has become obsolete. Instead, limited surgical intervention is recommended when indicated; this consists of incision and drainage of abscesses when they occur during therapy, and excision of tissue hopelessly devitalized by suppuration and necrosis. Penicillin is administered intramuscularly in either the aqueous form, in doses of 500,000 units every 8 hours, or a repository form containing a combination of 100,000 units of aqueous penicillin G

and 500,000 units of procaine penicillin administered every 12 hours initially, then every 24 hours. If there is no response within 48 hours after penicillin therapy has been instituted, and the infecting organisms are resistant to penicillin, substitution of erythromycin or one of the "broad spectrum" antibiotics may be effective. Bacitracin (500 units per ml.) or penicillin (5,000 units per ml.) may also be injected directly into the lesion, though with increasing evidence of the efficacy of parenteral antibiotic therapy most surgeons now prefer to employ that route exclusively.[21, 22] Extensive carbuncles with systemic manifestations are usually best treated in a hospital.

In some cases, furuncles are recurrent. Usually, this is due to one or more of the predisposing factors previously listed, although in some instances the most exhaustive studies do not reveal any apparent cause. The most thorough attention to skin hygiene and to the nutrition and the general health of the patient is important. Trauma, such as the pulling of hairs from the nares, the wearing of chafing dirty clothes, or the rubbing or the fingering of the lesions, is avoided. The use of soap containing hexachlorophene may be instituted for routine bathing. The possibility of an underlying allergic dermatitis should be borne in mind, and, if present, suitably treated. Sugar metabolism should be investigated, and controlled if abnormal. A restriction of carbohydrates, even in the absence of demonstrable elevation of the blood sugar, may be beneficial. It is difficult to evaluate the utility of toxoids and vaccines. Of all these preventive measures one may state that they are certainly not uniformly successful but that in some cases they seem to be effective in checking recurrence.

It is now recognized that in chronic furunculosis the upper respiratory tract, particularly the anterior nares, even though apparently healthy, is often colonized with *Staph. aureus*. Occasionally, instead of the nose, the eye, the ears, the axilla or some other region is the reservoir from which infection continues to be distributed. Infection also persists in the neighborhood of a lesion until it is completely healed.

According to Valentine and Hall-Smith,[25] the facts of the situation, i.e., the carrier state, should be explained to the patient, and treatment of the "carriage" area should be carried out with an antibiotic locally twice daily for 2 to 4 weeks, in addition to treatment of the local lesion. Their results with this method were good. When reinfection with a strain resistant to the antibiotic employed took place, the results were somewhat more equivocal, but colonization of the "carriage" area with a fresh strain did not usually lead to clinical relapse. For the surgeon's guidance, bacteriologic studies of swabs taken from the lesion, the nose and the eyes are very desirable. The need for further cultures will depend on the clinical results.

LYMPHANGITIS[16, 21]

Etiology and Symptoms. Acute lymphangitis is an infection which extends along the lymphatic vessels. It frequently originates from a superficial wound, which may be small, such as a pinprick, and spreads proximally through the lymph vessels to the lymph nodes. The hemolytic streptococcus is the most common causal organism. Lymphangitis is most fre-

quently encountered in the upper extremity, and it is particularly prevalent among physicians and nurses, whose occupations predispose to puncture wounds of the hands with instruments soiled by infected material. Lymphangitis of the upper extremity often occurs from hand infections resulting from a puncture wound with a needle, a pin or a wire, or from a blister or an infected incised wound. Lymphangitis of the lower extremity may occur from an infected blister, callus or toenail, or from interdigital fungal infection or the numerous scratches or bites on the legs of children.

A patient suffering from lymphangitis will generally give a history of having suffered one of the foregoing wounds of entry for the micro-organisms, or he may not remember having had a wound. The limb is swollen and painful, though the initial edema does not pit on pressure, as in thrombophlebitis. It is tender to palpation, but particularly along the course of the affected lymphatics. The latter may be recognized by their giving rise to *red streaks* which run up the extremity. These red streaks are tender to palpation, as are the regional lymph nodes.

The general condition of the patient shows malaise and prostration. There may be a chill if the infection is severe, and the temperature and the pulse are both elevated. As in any infection, the severity will vary according to the virulence of the organism, the degree of contamination and inoculation and the resistance of the patient. The onset of symptoms and the systemic reaction will be more fulminating in the severe infection, and the local signs will develop more rapidly in those cases. Injudicious incision or other trauma, neglect or continued functional use of the part favors rapid spread and complications such as septicemia and even death. There is little tendency for abscesses to form. When local breakdown of tissue does occur, it is characterized by either gangrene of the overlying skin or the development of thin, watery pus.

Treatment. Much of the fear of lymphangitis has been dispelled by early proper treatment with the sulfonamide or the antibiotic drugs. Their extraordinary efficacy in combating these infections has been proved beyond question. Thus, the treatment of acute lymphangitis consists primarily in the control of its invasive characteristics by antibiotic therapy, rest and heat, and secondarily in incision and drainage of collections of pus and necrotic tissue should they present themselves. Penicillin is the drug of choice in hemolytic streptococcal lymphangitis, although sulfadiazine or one of the "broad-spectrum" antibiotics may be employed in lieu of either of these drugs. Usually the lymphangitis will subside in 24 to 48 hours with this therapy, but the treatment should be continued for 2 or 3 days after the inflammatory process has disappeared. It is usually advisable, even in the less severe cases, to confine the patient to bed during the acute phase of the infection, as rest and elevation are the most effective therapeutic measures. In mild cases, enforced bed rest may seem to be drastic treatment from the patient's viewpoint, but a safe and a rapid recovery is thereby ensured. Adequate intake of fluids is of value. Application of heat may be instituted for the comfort of the patient, though this is no longer as essential to resolution of the infection as in the prechemotherapy era. In the leg, the immobilization which is accomplished

by elevating the part on pillows is sufficient. After control of the invasive characteristics of the infection by penicillin or one of the other chemotherapeutic agents, drainage of the local lesion may be instituted in the event that pus or necrotic tissue has formed.

Prophylaxis. Scrupulous cleanliness and aseptic care of small lacerations, blisters and other open lesions of the extremities will do much to prevent spreading infection. The prophylactic use of penicillin (a single intramuscular injection of 300,000 units of procaine penicillin) may be advisable for a surgeon who has pricked his finger with a needle while working in a field known to contain virulent hemolytic streptococci.

CELLULITIS[1,16,21]

Etiology. Cellulitis is a diffuse inflammation of the tissues by pyogenic bacteria. It differs from lymphangitis in that it is not limited to the lymphatic vessels. As in lymphangitis, cellulitis arises from an infected wound, which is usually superficial, and the offending organism is most often a hemolytic streptococcus, although a staphylococcus or mixed flora may be involved, particularly if localization is hindered by continued movement or trauma of the affected part. The portal of entry may be an obvious open laceration, ulcer, callus or blister; or it may be a small invisible puncture wound or abrasion. The spread of infection is usually less rapid, and the systemic reaction is not as severe as in acute lymphangitis.

Diagnosis. Increased heat of the affected part, diffuse redness, slight pain and tenderness, and a soft edema of the skin and the subcutaneous tissues are characteristic of cellulitis. Care must be taken to differentiate between a primary cellulitis and the indurated skin over a deep abscess which has become localized and is pointing toward the surface. Timed incision and drainage are indicated in the latter case, whereas conservative therapy is advisable in cellulitis.

Treatment. Rest, elevation of the part if an extremity is involved, and the application of heat constitute the essential therapeutic measures in the treatment of cellulitis. Penicillin, administered as already described in the treatment of lymphangitis, usually produces a rapid control of the infection and resolution of the inflammatory process. Not uncommonly, however, the infection will become localized, and a discrete abscess will form. When induration has diminished and the abscess has become fluctuant and well walled off, incision and drainage will facilitate recovery. No clinical response after 48 hours of penicillin and supportive therapy should lead to suspicion of penicillin-resistant organisms as causal of the infection, and change to another antibiotic may be advisable.

ERYSIPELAS[21]

Symptoms. Erysipelas is an acute infectious disease of the skin or, more rarely, of the mucous membranes, due to infection of the superficial lymphatics, particularly in the corium, by the hemolytic streptococcus. It often originates in a wound. It occurs most frequently in individuals past midlife, and, in the absence of prompt adequate specific therapy, there is a definite tendency to recurrence of the infection. The infection seems to have seasonal variation, appearing most often during the fall and the spring. The disease is characterized by an abrupt onset of systemic symptoms,

usually with a chill, headache, severe malaise and fever. The local lesion, which occurs about the face or the forehead in the majority of cases, is distinctive. The skin becomes hot, red and indurated, with a well-defined, palpably raised and sharply demarcated margin. The burning local pain and redness which occur may precede the systemic reaction, although the skin lesion usually does not appear for 6 to 12 hours after the onset of symptoms. The redness and the induration spread by direct continuity along the periphery, often quite rapidly, and vesicles or even large blebs may form in the area of earlier involvement as the lesion progresses.

Treatment. The treatment of erysipelas usually cannot be carried out in the ambulatory patient, although mild cases without marked systemic symptoms may not require hospitalization. The description and a brief discussion of the present-day therapy of this disease is especially indicated, as erysipelas in its milder forms or earlier stages may be seen first in the physician's office or in the outpatient clinic and abortive treatment given.

Prophylaxis. Disinfection of the hands of attending physicians and nurses and scrupulous care of contaminated instruments are essential Care of these patients should not be conducted by those who must attend obstetric or surgical patients simultaneously, although strict isolation is not necessary.

Antistreptococcal chemotherapy is the most important single agent in the treatment of erysipelas, and it has made older forms of treatment obsolete. While there has been a high degree of success with the sulfonamides in combating erysipelas, penicillin is now considered to be the treatment of choice. It is given intramuscularly, in 600,000 unit dosages once or twice daily, and it is continued until the patient has been afebrile for at least 3 days. Supportive measures, including the generous administration of fluids, are essential for the comfort and the safety of the patient. Recurrence, which is controlled by additional treatment, is seldom as severe as the original attack; lymphatic damage is often responsible for persisting swelling, especially in the extremities, but the symptoms and the signs characteristic of the original attack are considerably less pronounced.

NECROTIZING FASCIITIS. HEMOLYTIC STREPTOCOCCAL GANGRENE[17,24,26,27]

Necrotizing fasciitis (fascial necrosis) is a type of infection formerly regarded as rare in the United States, and it is still uncommon, though its incidence is apparently increasing. In 1952, when Wilson[27] reported 22 cases from a Dallas hospital, he had knowledge of 7 others. His explanation of the increased incidence, which is probably correct, is that in the past the infection in its early stages was often mistaken for cellulitis or erysipelas and treated conservatively. Then, when it had progressed to the gangrenous stage, the diagnosis of wet gangrene was made and amputation was sometimes performed without recognition of the true condition Starr emphasizes that it is a frequent cause of persistent soft-tissue sinuses.[24]

Necrotizing fasciitis may originate in an operative wound, in a traumatic wound, abrasion or contusion, or in an insect bite. It may also appear spontaneously. It may be fulminant,

involving the entire extremity in 24 hours; or it may remain dormant for weeks and then spread rapidly, or it may be slowly progressive. It tends to appear in the fascio-aponeurotic zones of the body, that is, the thigh, the axilla, the palm, the sole and the lumbodorsal region.

The pathognomonic objective manifestation is subcutaneous or fascial necrosis manifested by extensive undermining of the skin. Wilson recommends that the undermining be demonstrated by passing a probe or a hemostat along the plane just superficial to the deep fascia. this cannot be done in simple cellulitis or erysipelas. The skin overlying the affected area may present edema, cellulitis, erysipelas, ecchymosis, bullae and gangrene. Gangrene is a late manifestation and, therefore, should not be regarded as of diagnostic import. An edematous area of skin should arouse suspicion. If it is hypesthetic or anesthetic to pinprick, the chances are that necrotizing fasciitis is present and that the cutaneous nerves have been involved in the necrosis of the subcutaneous fascia. Starr recommends radiography with Lipiodol, which will reveal a sinus remarkable for its length and tortuosity and which will also eliminate bone lesions

Meleney,[17] who published the largest series of cases on record prior to Wilson's publication (20, from China, in 1924), named the infection *hemolytic streptococcic gangrene*, for the obvious reason that the hemolytic streptococcus was cultured from each of his cases. Cases presently being reported, especially those of the chronic type, seem to be caused chiefly by hemolytic staphylococci.

Chronic infections may be asymptomatic, but patients with fulminant infections are seriously ill. The mortality of the acute form was formerly 20 to 50 per cent, and it is still between 5 and 10 per cent. As soon as the diagnosis is made, therefore, surgery should be instituted, without delay for laboratory confirmation. Antibiotic therapy alone is not adequate. Progression to gangrene can occur under it if surgical measures are not employed also. As Starr points out, the condition is essentially fascial sequestration, and it would be expected that antibiotic therapy would not be effective because it does not act in the presence of dead tissue.

The treatment, which should be carried out in a hospital, therefore, is extensive incision throughout the entire area of involvement, to the point, as Wilson puts it, at which the instrument or the fingers can no longer separate the skin and the subcutaneous fascia from the deep fascia. If the lesion is circumferential, the incision must be circumferential also. The affected area has a characteristic appearance. The tissues are edematous and thin. Sanguineous, turbid fluid exudes from the areas incised, but purulent collections are not the rule. The subcutaneous fat is hard and edematous or necrotic, and the affected fascia is dead white or mottled, or stringy, ragged, gray, or occasionally hemorrhagic, depending upon the stage at which the patient is seen. Dead tissue must be completely excised. The wound is loosely packed with plain gauze, and is closed 4 to 8 days later with stainless-steel wire sutures, which are left in place for 2 weeks. Buried sutures should be used only if they are required for the ligation of large vessels.

Penicillin or some other antistaphylococcal antibiotic such as tetracycline or chloramphenicol is used systemically both before and after operation, in full dosages.

Patients with acute necrotizing fasciitis *may show marked physiologic* disturbances. Even if there is no external loss of fluid, extracellular fluid volume deficits may occur. There may be rapid destruction of red blood cells, sometimes associated with jaundice, as well as ionic calcium deficits, probably because calcium is sequestered in the area of fat necrosis. The statement of these disturbances implies the corrective measures which must be undertaken.

ERYSIPELOID OF ROSENBACH[9,23]

Etiology. Erysipeloid of Rosenbach, also known as erythema serpens or erythema migrans, is an acute cutaneous infection caused by the organism of swine erysipelas, *Erysipelothrix rhusiopathiae*. This disease has come to be of no small importance in industrial medicine. In a series of about 600 cases, Gregory found that contact with fish or lobster was mainly responsible. The hand, and especially the fingers, are the usual sites of inoculation (Fig. 83)

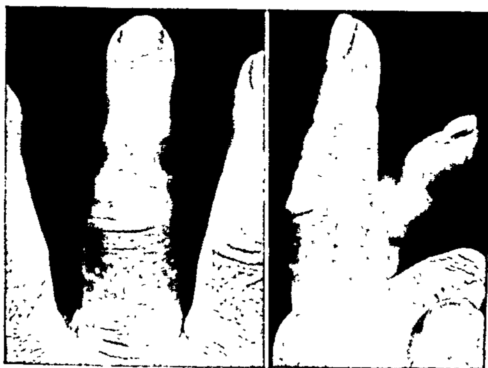
Symptoms. Initially the lesion may appear in the form of a paronychia. It is associated with throbbing pain, itching and burning, and malaise, and it appears as a smooth, circumscribed, more or less edematous inflammation which does not pit on pressure The distinctive feature of the disease is the purplish-red color of the erythema. This is of diagnostic value. The erythema extends slowly from the periphery, producing a sharply defined elevated zone, and, as it extends, the involved areas clear centrally. Involution occurs without desquamation. Suppuration almost never occurs.

Lymphangitis and lymphadenitis occur in some patients. If the fingers are involved, movement may be difficult, *and this stiffness is out of proportion* to the degree of soft-tissue swelling. Arthralgia may occur in the fingers, the wrist, the elbow, and even the shoulder joints. Occasionally, this persists for a time after the clearing of the skin lesions. Rarely is there swelling of the painful joints, and roentgen changes have been reported in cases of long-standing arthralgia.

Diagnosis. The disease is almost always confused with erysipelas, from which it may be distinguished by the purplish-red rather than the fire-red color and by the fact that the peripheral zone is never raised and sharply demarcated as in erysipelas. Furthermore, the site of infections, usually the hands, and the lack of severe systemic reaction aid in the diagnosis of erysipeloid.

The diagnosis is not difficult if the condition is kept in mind as a possibility. History of contact with fish or animal material should arouse suspicion. Strict limitation of the process to one location, usually the hand, manifested by the erythematous, edematous lesion with tenderness of the joints on lateral pressure, and the slow progression with limitations to the fingers and the hand, should clinch the diagnosis.

Treatment. Sneath, Abbott and Cunliffe[23] found that the causative organisms, *Ery. rhusiopathiae*, are relatively uniform in their sensitivity to penicillin, chlortetracycline and chloramphenicol. Gregory[9] did not have much success with the use of the sul-



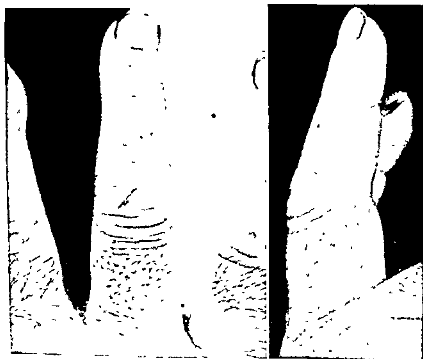


Fig. 83. (*Top*) Erysipeloid of Rosenbach in a butcher following injury by a meat bone Appearance of finger after 4 days of sulfonamide therapy (*Bottom*) Appearance of finger after 3 days of penicillin therapy. (Official U. S. Navy photographs)

fonamides or local applications such as Ichthyol ointment He now uses neomycin sulfate, 0.5 mg. per Gm., locally, in conjunction with 300,000 units of penicillin intramuscularly on 2 or 3 consecutive days. On this regimen over 90 per cent of the patients respond satisfactorily, and the severe deep-seated pain and throbbing disappear in most cases in 24 hours. Antibiotic therapy has now supplanted the use of antiserum and other forms of treatment.

ACUTE LYMPHADENITIS[1,13,16,21]

Etiology. Lymphadenitis is an inflammatory process of the lymph nodes which is almost invariably due to lymph-borne infections, although occasionally it may result from blood-borne infections or direct trauma. While any organism capable of producing infection in tissues may produce lymphadenitis, streptococci and staphylococci are most frequently responsible. The infection is usually secondary, but it may be primary or it may be superimposed on primary pathology of lymphatic tissue. Single nodes or groups of nodes may be affected, or involvement may be widespread, depending on the nature of the etiologic agent.



Fig. 84. Acute postcervical adenitis following scalp infection Note small infected area of the scalp and mass of lymph nodes below it

Diagnosis. A regional lymph node or chain of enlarged nodes often provides a clue to the diagnosis. Thus, acute inflammations of the neck may follow oral sepsis, scalp sepsis (Fig. 84), superficial wounds of the head or infections of the tonsils or the respiratory tract. Chronic infectious cervical adenitis may be due to delayed resolution of acute cervical adenitis, or it may be due to tuberculosis, syphilis, anthrax, actinomycosis or infection superimposed upon primary lymphadenopathy due to other causes In the upper extremity, the antecubital and the epitrochlear glands may be involved early in infections involving the ulnar side of the hand. In infections of the radial side of the hand, the axillary glands are first to be involved. Infections of the middle finger may drain into either the antecubital or the axillary glands, but in some instances they drain directly into the supraclavicular glands. Enlarged inguinal nodes occur in sepsis of the lower extremity; e.g., in interdigital infection, infected varicose ulcer and cellulitis or infection in the rectal or the genital area. Tuberculous psoas (cold) abscess may present in the inguinal area. Ulcerating lymph nodes, regardless of their location, suggest tuberculosis, tularemia, anthrax, actinomycosis, specific venereal disease or malignancy. Differentiation between

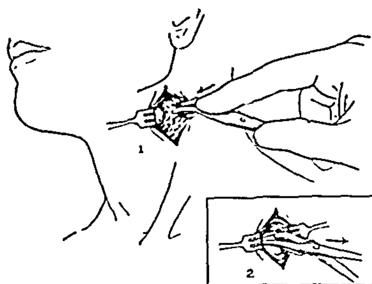


FIG. 83. Method of opening suppurative adenitis with a hemostat. After incising the skin, the closed hemostat is plunged through the wall of the abscess, the index finger guarding the tip so that the hemostat does not pass too deeply. When the abscess cavity is entered, the blades are spread apart and the hemostat is withdrawn, the opening in this way being enlarged bluntly.

infection and malignancy is important and necessary.

Course. The course of the inflammatory process within the lymph nodes may vary greatly, depending particularly upon the virulence of the invading organism, the nature of the primary infection, the resistance of the patient and the management of the lesion. As a rule, the primary lymphadenitis appears in the neck, the axilla or the groin at the height of the primary infection. There is often no evidence of intervening lymphatic involvement. The lymph nodes become tender, hard and enlarged. In the majority of cases, bacterial lymphadenitis will quickly subside when the primary infection has been adequately controlled. In some instances, necrosis and abscess formation will result. The infection may extend beyond the lymph nodes and involve adjacent tissues, thus producing a spreading cellulitis or a fascial-plane infection.

Treatment. The treatment of lymphadenitis must be directed primarily toward the eradication of the original portal of infection. This holds true whether the lymphadenitis is of a fulminating suppurative type or of a low-grade smoldering type. The management of the primary lesion will, of course, depend entirely upon its nature, but the most conservative measures should be used in the presence of acute spreading infections.

Rest is important during the acute stages. In severe infections, rest in bed with elevation of the affected part, if the primary lesion involves an extremity, is advocated. Immobilization with dressings, splints or even plaster affords a means of complete rest for an affected extremity in an ambulatory patient. Heat applications, as for any acute inflammation, are indicated.

When suppuration occurs, incision and drainage are necessary. Incision too early, however, will tend to spread the infection. If there are no systemic symptoms, it is best to delay incision until the induration has practically disappeared and a localized abscess has formed. In the neck, it is frequently difficult to demonstrate fluctuation in the enlarged deep nodes. However, a lymphadenitis that per-

sists as an enlarged, hard swelling for 10 days or more after an acute infection has subsided usually is found to be the seat of a suppurative necrotic process, and incision is indicated.

In incising a lymphadenitis, it is best to make a small incision over the most prominent part of the abscess and then to enter the suppurative process with a closed blunt hemostat. When pus is found, the hemostat is removed with the blades open, thus enlarging the wound (Fig. 85) The wound is then explored with a curved hemostat or a probe, and the incision is enlarged in the direction of the longest diameter of the abscess, the edges of the wound being held open with rake retractors or Allis forceps. When the abscess is completely open,

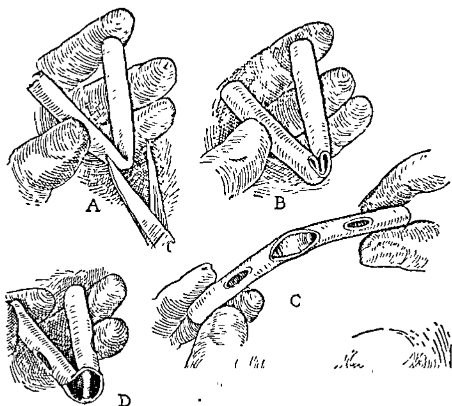


Fig. 86 Double-barreled rubber-tube drainage for deep abscesses



FIG. 87. Dermatitis repens of the palmar surface of the index and the middle fingers. Note the blisterlike swelling distended with purulent fluid and slight amount of hyperemia round the edge of the blisters

the lips of the wound are filled loosely with gauze. In suppurative lymphadenitis of the neck, the same method of opening the abscess is used, but frequently it is inadvisable to enlarge the opening to the full extent of the abscess because of important structures which must be protected against trauma. In such cases, the wound is prevented from closing too rapidly by means of a double-barreled rubber tube (Fig. 86). This tube, because of elastic pressure, keeps the wound open and permits drainage until it is removed.

Penicillin is usually the drug of choice in pyogenic infections, with chlortetracycline, chloramphenicol and oxytetracycline as alternates. Streptomycin is specific for tuberculosis and for tularemia, chlortetracycline or oxytetracycline for lymphopathia venereum. Penicillin, chloramphenicol or the tetracycline antibiotics may be used with benefit in actinomycosis.

DERMATITIS REPENS

Etiology. Dermatitis repens is the name given to a low grade extending recurring pyodermia. It usually begins in the region of the nails, and it occurs almost entirely on the hands. The onset generally follows an injury, although it may be difficult to elicit the history of this.

Signs and Symptoms. The initial lesion is a marked edema of the skin, followed soon by the appearance of a pus-containing vesicle. Mostly, the process involves the palmar surface of the tip of the finger near the nail (Fig. 87). The lesion progresses with an undermining of the epidermis and the formation of pustules. As it extends, there is often a tendency toward a central denudation with the most active involvement occurring in the extending borders. At times, however, the central primary point of involvement may completely heal while the lesion extends on the periphery.

The symptoms of dermatitis repens are not particularly striking. There are tenderness and some pain with the inflammatory reaction, but the discomfort is not nearly as marked as in

other acute infections of the fingers. The chief distressing symptom of the clinical picture is the tendency of the lesion to progress and not to respond to the usual forms of therapy.

Treatment. When the pus-containing vesicle is ruptured, the pus expressed may be staphylococcal or streptococcal. Removal of the loose skin of the vesicle discloses a raw tender area of derma. The overlying epiderm must be excised to the place at which the true skin and the epidermis are still in contact. Moist dressings of bacitracin (500 u./ml.) or neomycin (0.5 mg. per ml.) locally and penicillin systemically have proved to be of value. The disease seems to be self-limiting, but the therapy suggested apparently shortens its course considerably. Serious finger or hand infections seldom result from it.

ABSCESSES

Etiology. Superficial or deep local abscesses are the residual complications of such infections as lymphadenitis, cellulitis, erysipelas and suppurative thrombophlebitis. Occasionally, an abscess results from contamination at the time of a direct penetrating wound.

Treatment. Incision and drainage, after localization, are the only adequate treatment. A liberal incision, *placed in a direction to afford direct* drainage, is advocated. The direction of the incision should also be so chosen as to avoid injury to important adjacent structures and to prevent disabling or disfiguring scars. In deep abscesses with extension along the fascial planes or into a closed fascial space, an accurate anatomic knowledge of the part is required to obtain adequate drainage without injury to important structures or impairment of function. The advantages of a bloodless field, easily obtained with an inflated blood-pressure cuff, should be remembered when deep infections of the extremities are being incised.

Drain material, such as plain fine mesh gauze, which favors and does not prevent escape of wound secretion and can easily be removed, is advocated. Drains aid in securing hemostasis and in keeping the lips of the wound open until inflammatory induration establishes an adequate drainage tract. They may be removed within 48 to 72 hours. By that time they have served their purpose, and, once removed, need not be replaced.

The choice of anesthesia for incision and drainage will depend upon the site and the size of the abscess, the equipment available and the mental make-up of the patient. Superficial abscesses, furuncles and suppurative lymph nodes may often be incised in the office or the clinic under local skin infiltration with procaine. An 0.5 or a 1 per cent solution of procaine is injected into the skin along the line of the proposed incision. It must not be diffusely infiltrated into the normal tissues about the abscess for fear of spreading the infection. An intradermal wheal by use of a fine gauge needle is all that is necessary. The anesthetized skin is then grasped with a *towel clip, or between two clips,* and lifted up while the incision is made. Deep pressure over the inflamed area is thus avoided and painless incision can be performed (Fig. 88).

When general anesthesia is necessary for ambulatory patients, Vinethene has proved to be most valuable because of its short induction period and rapid recovery time. Pentothal sodium, 2.5 to 5 per cent solution, is also a valuable general anesthetic for

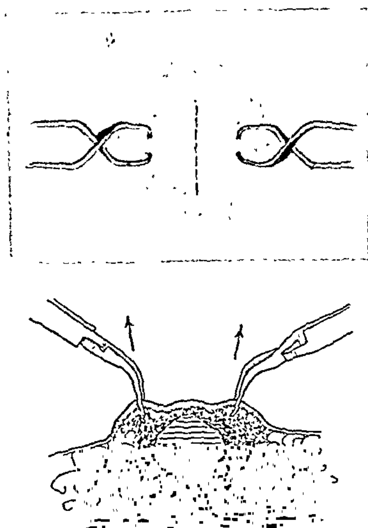


FIG. 88. Method of incising a superficial abscess under local infiltration anesthesia. The skin and the superficial tissues overlying the abscess cavity are infiltrated in the usual manner. Towel clips are inserted into the anesthetized skin on either side of the proposed line of incision. An assistant lifts up the towel clips as the incision is made into the cavity. In this way, pressure on the abscess by the knife during the incision is avoided, as is also the severe pain that accompanies such pressure. Following incision of the abscess, the towel clips on the wound edges may be used as retractors to aid in exposing the cavity.

ambulatory patients when only short operative procedures are contemplated. Antibiotics are employed as for cellulitis.

CHRONIC UNDERMINING BURROWING ULCERS[15,20,21]

Etiology. In 1935, Meleney first described as a clinical entity a chronically progressive nongangrenous ulceration of the skin and the subcutaneous tissues caused by a microaerophilic hemolytic streptococcus, and gave the lesion the descriptive name "chronic undermining burrowing ulcer." Personal experience and recent reports in the literature indicate that this disease is not exceedingly rare and may be encountered in the outpatient clinic or the physician's office (Fig. 89). It is of importance be-



FIG 89. Chronic undermining burrowing ulcer of the hand.

cause it is often unrecognized and progresses to involve large areas of the surface of the body, because it does not respond to the usual forms of treatment and because it is not infrequently fatal.

Description. A composite picture of the disease is best given from a subsequent report by Meleney:[17]

> It is a chronic infectious process which may occur at any age, in either sex, and on any part of the body surface. It is caused by the invasion of a micro-aerophilic hemolytic streptococcus which may enter the tissues either through an accidental wound or through an operative wound, or it may invade a lymph gland from a distant source and not produce the lesion at the portal of entry but only after a period of activity within the gland. The lesion is characterized by prolonged suppuration, with the gradual development of an ulcer with undermined, rolled-in margins, and sinuses which tend to burrow beneath the skin or into the deeper tissues along lymphatic channels, veins, or fascial planes. The ulcer gradually, but almost irresistibly, enlarges. The base is covered with grayish, gelatinous, anemic, shaggy granulations. Hematomas occasionally form spontaneously in the superficial layers of the granulation tissue. The infection frequently produces daughter ulcers by a perforation of the skin from beneath or by secondary inoculation of the skin from the surface. If a perforation occurs from within, the daughter ulcer gradually enlarges and may fuse with the main ulcer or leave a bridge between them, which may become completely surrounded by epithelium on the deep, as well as on the superficial, surface. There is usually a moderate fever and moderate pain in the wound. At times, the temperature may reach 103° F. every day for a period of days, but usually it remains at a lower level. In some cases in which the threshold for sensitivity is low, pain may be intense, and after prolonged illness completely shatter the patient's morale. The infection rarely involves muscle or bone but when it invades bone, it is almost impossible to eradicate it. The organism rarely invades the blood stream, but occasionally it may be recovered from the blood, and in such cases may produce metastatic foci in other parts of the body. The infection rarely invades the blood vessels, but in long-standing cases it may do so, producing thrombi in them or eroding their walls, causing severe or fatal hemorrhage. In long-standing cases amyloid degeneration of the liver, spleen, and kidneys may develop.

Treatment. Early diagnosis is important. Diagnosis depends not only upon recognition of the characteristic features of the disease, but also on the early identification of the organism by anaerobic culture.

This infection has not proved to be readily responsive to the usual *chemotherapeutic agents.* Meleney and his associates[20] feel that bacitracin, to which the causative organisms are susceptible, is now the drug of choice. The dosage is 20,000 units given intramuscularly, sometimes combined with penicillin in daily dosages of 600,000 units. The patient must be observed for possible nephrotoxicity due to bacitracin, and treatment is best carried out in the hospital.

Zinc peroxide[19] locally is also effective in halting the spread of the infection. Heat-activated zinc peroxide is made into a thick cream with sterile distilled water or physiologic saline solution and applied directly to all surfaces of the wound. After surgical exposure, the entire area is covered with waxed paper, oiled silk, petrolatum gauze or gauze impregnated with zinc oxide ointment. This covering enhances the action of the drug by keeping the cream moist and thereby favoring the liberation of oxygen. Also, the gas so liberated is kept

in contact with the wound surfaces. The cream should be reapplied every 24 hours. Skin grafting may be necessary to effect a closed wound.

CHRONIC PROGRESSIVE BACTERIAL SYNERGISTIC GANGRENE[18,26]

Progressive bacterial synergistic gangrene is precisely what the name implies. The tissues are invaded simultaneously by a micro-aerophilic nonhemolytic *Streptococcus* and a hemolytic *Staph. aureus*, neither of which, alone and in pure culture, is capable of producing a significant infection. Recent observations suggest that the staphylococcic micro-organisms may sometimes be replaced by strains of *B. proteus*. The gangrenous lesion which these bacteria produce in synergism is always serious and may be fatal.

This type of gangrene is usually observed 7 to 14 days after drainage of an intraperitoneal or an intrathoracic infection; occasionally it appears earlier. In such cases, Meleney suggests that the word *postoperative* be included in the nomenclature. The infection may develop round a colostomy or an ileostomy several weeks after it has been created, or round a simple abrasion. It may also follow fungous infection

Changes are first observed in or near the wound, particularly if an operation has recently been performed, in the skin edges or about the tension sutures Only the cutaneous and the subcutaneous tissues are affected. Deep fascia and muscle remain intact, and often the deeper portions of a surgical wound heal while the superficial gangrenous ulceration spreads.

The gross appearance is characteristic. The affected area of the wound first of all becomes swollen and indurated and assumes a carbuncular appearance. Soon afterward the zonular aspect typical of this lesion becomes apparent. The center of the lesion, to use Meleney's description, is a shaggy, granulating ulcer which may, as time passes, become bright red and relatively clean. About it are 3 quite distinct zones. The first is a zone of gangrenous skin which has a typical yellowish or brownish-green mottled discoloration. This zone, which looks like suede leather, is from 1 to 3 or 4 cm. wide. Its inner margin is only slightly undermined. Firmly adherent to its outer margin is the second zone, which is raised and purplish. The inner, adherent margin of this zone is sharply defined and crenated, and is of a darker purple than the remainder of the circle. Its outer margin blends into a zone of brilliant erythema, which is from 1 to 10 cm. wide. The subcutaneous tissues of the outer edges of the advancing ulceration are heavily infiltrated with polymorphonuclear leukocytes. Hyperemia is marked, but there is no thrombosis in the subcutaneous vessels, and the exudation, which is entirely superficial, is always purulent and never hemorrhagic. If the ulceration is not treated, or does not respond to treatment, it may continue to spread for weeks and months until large areas of the trunk are involved

The outstanding clinical characteristic of progressive bacterial synergistic gangrene is the exquisite tenderness of the indurated edges of the lesion. Systemic manifestations at first are limited to slight temperature elevations and a polymorphonuclear leu-

kocytosis. As time passes they become more severe, and death may ensue after a painful and an exhausting illness.

Diagnosis seldom offers any difficulty in view of the characteristic appearance of the lesion and the characteristic course. Routine bacteriologic studies, as Meleney emphasizes, may fail to confirm it because careful anaerobic cultural methods are required to identify the tiny colonies of micro-aerophilic nonhemolytic streptococci.

Formerly the only treatment for progressive bacterial synergistic gangrene was wide excision, followed by the application of zinc peroxide; in addition to being mutilating, it was not uniformly successful. The sulfonamides proved to be of no value at all. Although penicillin was brilliantly successful in some cases, it failed altogether in others, either because the primary organisms were resistant to it or because secondary contaminants also produced penicillinase. The report by Meleney and his associates[20] of 5 cases successfully treated with bacitracin, in 4 of which penicillin had proved to be ineffective, seems to make the administration of bacitracin the treatment of choice. As soon as the diagnosis is made, which should certainly be no later than the third or the fourth week, when characteristic zone formation has occurred, bacitracin by intramuscular injection is started in a dosage of 20,000 units and is repeated every 6 to 8 hours. Urinalyses and determinations of the blood urea nitrogen or nonprotein nitrogen should be made every third day. The mere appearance of albumin or casts in the urine does not, however, usually require withdrawal of the drug. This lesion is best treated in hospital.

TETANUS[7]

Tetanus is an acute disease caused by the action on nerve tissue of a diffusible exotoxin produced by *Clostridium tetani.* The portal of entry may be located in any part of the body, but most often tetanus occurs in wounds of the feet, the calf, the thigh, the buttock or the axilla. A history and usually physical evidence of a wound of entry for infection are present. Nail-puncture wounds, splinter injuries, cartridge or other burns and traumatic wounds are common portals. Superficial suppuration under a gauze dressing or a crust provides sufficient anaerobiosis for the tetanus bacillus. The incubation period varies between 4 days and 3 weeks, dependent somewhat upon the character, the extent and the location of the wound

Surgical Prophylaxis. The surgical prevention of tetanus is based upon the fact that *Cl. tetani* is a strict anaerobe, which means that its spores can germinate and give rise to toxin-producing actively growing bacilli only in an environment free from oxygen. It follows that all open wounds of violence must be carefully débrided, all necrotic tissues and foreign bodies being removed with as little trauma as possible. If the tissues in the wound following débridement have an adequate blood supply, then all parts of the wound may be considered to be sufficiently oxygenated, and tetanus spores, even if they are present, do not find conditions suitable for germination Conversely, if débridement has not been adequate, if the wound contains foreign bodies, blood clot and areas of necrotic tissue, or if the blood supply is precarious, then conditions readily become suitable for the germination of spores and the production of toxin Puncture wounds, particularly if contaminated, may require in-

cision. The practice formerly in vogue of cauterizing a puncture wound, as one sustained by stepping on a rusty nail or rake, is now frowned upon as being not only needlessly painful, but also as favoring the development of anaerobic conditions because of the tissue damage resulting from the cauterizing agent.

Immunoprophylaxis. Active immunization with tetanus toxoid is desirable for those likely to be exposed to infection with tetanus. Mass application of this principle in the U. S. Armed Forces has reduced to almost nil the incidence of this disease. There is currently an increasing tendency to begin active immunization with tetanus toxoid in infancy or early childhood, the toxoid being administered concurrently with appropriate antigens to protect against pertussis and diphtheria. In addition to the initial immunization with the doses and the intervals between injections recommended for the particular form of toxoid used, another (reinforcing) dose should be given within a year and renewal doses at the time of each injury from which there is danger of tetanus. Reinjections in the absence of injuries should probably be kept up with intervals no longer than 4 years. It is also important that the person should have with him at all times a record of his immunization in case of injury. Tetanus toxoid under such conditions has proved to be a more efficient and a less dangerous method of prevention than tetanus antitoxin.

In the absence of adequate previous immunization with tetanus toxoid, prophylactic use of tetanus antitoxin is recommended when wounds have been acquired in regions in which tetanus is prevalent and in all cases in which contaminated material may be embedded in the wound. The usual recommended dosage for children under 12 years of age is 1,500 units; for adults, the prophylactic dose is 3,000 units. The duration of immunity induced thereby is 4 to 10 days. If the wound is not clean by this time, further passive immunization is indicated.



Fig. 90 Positive skin reaction to an intradermal injection of horse serum. The photograph was made 10 minutes after injection of 0.1 cc. of 1:10 dilution of the serum. (Therapeutic Notes, Parke, Davis & Company)

Sensitization Tests. Prior to the administration of tetanus antitoxin, it is wise to inquire if the patient has had previous serum injections (for diphtheria, tetanus and so forth) or whether he is allergic or asthmatic. In these cases, serum should be given with extreme care, but even those giving no history of allergy should first be tested for sensitivity to the serum.

In artificially sensitized individuals, that is, individuals who have had a previous injection of serum, the antitoxin may be administered subcutaneously without fear of producing results more serious than severe serum reaction.

The intradermal and the ophthalmic tests are now carried out with the serum which is to be given to determine sensitivity. A tuberculin syringe is used to measure accurately 0.1 cc. of the serum, saline is then added to fill the syringe to the 1.0-cc. mark, making a 1:10 dilution. This solution is thoroughly mixed and 0.02 to 0.05 cc. are injected intracutaneously. A reading may be made in 20 to 30 minutes. If there is no reaction, the entire dose of serum should be given subcutaneously, preferably beneath the skin of the abdominal wall. A positive reaction consists of a central blanched wheal with a surrounding zone of erythema (Fig. 90). Pseudopod formation is supposed to indicate marked sensitivity. A reaction about a subcutaneous injection in the deltoid region may incapacitate the patient, particularly if he is a laborer or one accustomed to frequent use of his arms in the course of his occupation.

If the reaction is positive, the ophthalmic test is made. This consists of placing a few drops of 1:10 solution of serum in the lower conjunctival sac of one eye. In a positive reaction there are congestion of the conjunctival sac, lacrimation and a sensation of burning and itching This usually appears within 10 minutes Marked reactions may be relieved by epinephrine, a 1:1,000 dilution dropped in the conjunctival sac If this test is positive, administration of the serum is to be avoided if possible because the test, though less specific than the skin test, seems to give a better indication of proper reaction. Bovine or goat antiserum, if available, may be substituted for horse serum.

Desensitization of Patient. If the ophthalmic test is negative but the skin test is positive, one should proceed with desensitization. This consists of the administration of small doses of dilute serum repeated in increasing amounts. Even with this slow process, however, mild or severe immediate reactions may occur. In the initial dose, 0.01 cc. of the 1:10 dilution is injected subcutaneously. On the succeeding half hours, increasing doses are given, 0.02 cc., 0.2 cc., 0.5 cc., 1 cc., 2 cc. No further dilution of the serum is necessary from then on. The dosage may be resumed by giving, in another half hour, 0.05 cc. of the undiluted serum followed every half hour by 0.1 cc. until the desired amount is administered. If at any time a mild reaction should occur, the preceding dose is repeated at the time of the next injection instead of giving a larger amount. Mild reactions may be controlled by 0.03 cc. of epinephrine, 1:1,000 dilution.

Serum Reaction. Immediate serum reactions may vary from mild faintness to severe, sudden collapse with cyanosis, dyspnea, vomiting and, occasionally, diarrhea. In such immediate reactions, a full dose (1 cc. ampule) of 1:1,000 epinephrine should be administered immediately. Atropine sulfate should be injected subcutaneously and artificial respiration instituted if necessary.

Delayed serum reactions, which usually occur 5 to 10 days after the administration of the antitoxin, are characterized by pruritus with urticarial eruptions, enlargement of the lymph nodes, arthralgia and, in severe cases, edema of the face, the hands and the feet. Moderate fever usually accompanies the reaction. The treatment is purely symptomatic. Epinephrine solution in oil or ephedrine, 50 mg. every third hour, may be used.

Morphine or codeine may be necessary for the arthralgia in severe cases. Benadryl and Pyribenzamine (antihistaminic drugs) may be useful.

Immunization. In the instance of an incomplete active immunization, combined toxoid-antitoxin may be given. The 1-cc. dose of tetanus toxoid combines with no more than 50 units of antitoxin and is antigenic when given with antitoxin. The toxoid series of injections is completed at an appropriate interval after the first dose.

In the U. S. Army, active immunization with tetanus toxoid is considered to be effective for 4 years, and booster doses given at the time of injury provide a prompt increase in circulating antibodies. The fluid- or the alum-precipitated toxoid may be used. The alum-precipitated toxoid is slowly released from the site of deposition, and immunization is completed with 2 injections at intervals of 4 to 6 weeks. Care must be taken to inject the alum-precipitated toxoid intramuscularly, because cold abscesses may follow subcutaneous administration. The fluid toxoid is more rapidly absorbed, is less apt to produce cold abscesses, and is given as a series of 3 injections, at intervals of 4 weeks.

ANTHRAX[8]

Etiology. Anthrax is an infectious disease caused by the *B. anthracis*, which occurs sporadically in man. The infection usually follows contact with some domestic animal or some animal product, such as wool, hides or hair. The external or the cutaneous form, due to direct infection through a cut or an abrasion, is the most common, but intestinal or pulmonary anthrax may result from ingestion or inhalation of the organism, either in the spore or the vegetative form.

Symptoms. The so-called *malignant pustule* of cutaneous anthrax develops at the point of accidental inoculation on some portion of the body habitually uncovered. The incubation period is within 7 days, usually less than 4. The first appearance is that of a small red papule, usually single, accompanied by itching and burning. A vesicle, surrounded by inflammatory edema, later develops. This soon ruptures, leaving an eroded, ulcerated base with a brown or a black slough. A number of small vesicles may appear on the neighboring skin, and the adjacent tissues are indurated. The regional lymph nodes usually become inflamed and tender. Freedom from pain in and about the initial lesion is characteristic, although there may be tenderness on pressure. This relative freedom from pain and absence of frank suppuration aid in differentiating the lesion from a furuncle or a carbuncle. The severe constitutional symptoms and the extensive local edema early in the course of the disease also make one realize that the lesion is more than an ordinary pyogenic infection. The black eschar with surrounding vesicles and extensive induration is characteristic of the fully developed anthrax pustule. The final diagnosis can be made by bacteriologic examination of smears and cultures from the lesion.

Treatment. Anthrax is another disease in which the introduction of antibiotic therapy has greatly altered the outlook. Since it became available, excision, incision and cauterization are no longer employed in the management of cutaneous anthrax. Antianthrax serum has also fallen into disfavor. It is now used only when there

is no response to antibiotic therapy.

Aqueous penicillin G, 300,000 units every 6 hours, by the intramuscular route constitutes the treatment of choice for anthrax. Chlortetracycline and oxytetracycline are also effective in this infection and are useful alternative agents. The sulfonamides are also useful adjunct drugs. The response to antimicrobial therapy is usually fairly prompt. The cutaneous lesion becomes localized, and anthrax bacilli *disappear from it in 3 or 4* days. The first sign of improvement is that edema ceases to spread and disappears entirely within 1 to 5 days. The papule becomes flat and dry, and the black eschar sloughs away, usually within 7 to 14 days. Ulcerations heal within the same period of time, but lymphadenopathy may persist for several weeks.

HUMAN BITES[6, 14]

Definition. Human bites are traumatic wounds inoculated with the organisms found in the mouth. The most common site for the lesion is over the metacarpophalangeal joint on the dorsum of the hand, when the clenched fist of one combatant strikes the teeth of his opponent. Sometimes the injury is intentional. Bites acquired by attendants caring for psychiatric patients and by policemen bringing in prisoners are not an uncommon occurrence. Finally, the injury may occur as a result of accidental puncture by utensils (forks) or instruments (dental) contaminated with human saliva. The aerobic and the anaerobic cocci, fusiform bacilli and spirochetes present in the mouth are thus transferred to a broken area *of the skin, into which may* also enter any or all of the bacteria present on the skin when the wound was incurred. Anaerobic streptococci seem to be the most important of these microorganisms, although, because they act in synergism with each other, none can be ignored. The spread of infection is by way of the tissue planes contaminated by the injury. The lesions include soft-tissue necrosis, cellulitis, abscess formation, tenosynovitis, thenar and palmar space infections, and dorsal subcutaneous and subaponeurotic space infections.

Prophylaxis. *Boyce's observations* on 183 (chiefly delayed and late) human bites treated at Charity Hospital of Louisiana, at New Orleans, confirm the observations of others that these are potentially dangerous injuries, especially when they are ignored or treated incorrectly. The general lack of comprehension of the pathologic process, he points out, combined with outright mismanagement, accounts for a major portion of the poor results which follow them. In the preantibiotic era, mutilating surgery and amputation of digits, or even of an extremity, were sometimes performed and an occasional fatality occurred.

Ideal prophylaxis in human bites of *the hand begins with cleansing the part* for at least 10 minutes with soap and water or with hexachlorophene soap or some detergent. Strong antiseptic solutions are never used. An atraumatic technic is used, and the depths of the wound receive special attention. Only then are the depth, the extent and the characteristics of the injury determined. Needless to say, this entire process must be performed with good anesthesia of the affected part and gentle handling of the tissues. Débridement is carried out if gross *devitalized tissue is present.* It is never advisable to attempt primary closure of these wounds, and tightly packed

gauze in the wound is avoided. The hand is splinted in the position of function, whether or not surgery is indicated. In any event, penicillin therapy (300,000 units of the procaine type intramuscularly) is begun as soon as the patient is seen, and all surgery is performed under its protection.

Treatment. If, as often happens, the victim is not seen until the infection is established, the affected part resembles an ordinary cellulitis, with or without lymphangitis and constitutional symptoms, and is very painful, especially on movement. There is a slight-to-moderate discharge, frequently foul in odor. The infection spreads progressively with time.

The main reliance in therapy of the infected human-bite wound is on chemotherapy – penicillin, bacitracin, tetracycline or chloramphenicol. All are effective and are given in standard doses. The part is cleansed and swathed in dressings, and, if it is the hand that is involved, it is splinted in the position of function and kept elevated. Incision and drainage are resorted to after localization has occurred. Necrotic tissue, if it is not extruded spontaneously, is meticulously débrided. Physical therapy, repair of severed tendons, etc., are delayed until after the infection has resolved and the wound has healed.

ANIMAL BITES

Treatment. Bites inflicted by dogs, cats and other domestic animals, while usually limited to minor abrasions, may result in lacerated or penetrating wounds which are usually badly contused. Such wounds demand the careful immediate care given any potentially infected contused wound. In addition, the possible transmission of rabies, a specific infectious disease of mammals, must always be considered in the treatment of animal bites.

The first step in the treatment of a bite wound should be careful cleansing of the wound and the surrounding skin area. Good anesthesia, with either an adequate local or regional block, or with general anesthesia, is essential. All badly traumatized and nonviable tissue should be débrided. Primary suture of the wound usually is not advisable.

If the animal concerned is rabid, has suggestive symptoms, or cannot be identified, it is recommended that the wound be treated as if rabies might be produced. Fuming nitric acid formerly was recommended as a local application. More recent researches seem to show that irrigation of the wound with 20 per cent soap solution gives equally good results. The protection against rabies in experimentally infected animals, either by fuming nitric acid or by soap-solution irrigation, decreases rapidly the longer the treatment is delayed. A single dose of procaine penicillin, 300,000 units for prophylaxis against pyogenic infection, is advisable.

RABIES[4,10]

Rabies, or hydrophobia, is usually fatal encephalitis due to a neurotropic virus acquired from a rabid animal as a result of a bite. Most commonly it follows bites round the head. Although rabies is now well under control in regions in which public health service programs are in operation, sporadic outbreaks do occur from time to time. Dogs are most commonly responsible for transmitting the virus to men, although cats, wolves, skunks, bears and other animals may do so on occasion. Although most human cases

occur during hot weather, the disease affects lower animals in all seasons.

Prophylactic Treatment. Prevention and control of rabies entail the impounding of stray ownerless dogs and the restraint of other dogs by their owners. In many communities, mass immunization of the canine population is being actively carried out.

Following a bite by a mammal, the wound or the contaminated area should be cleansed thoroughly with soap or a detergent and water. Puncture wounds should be laid open to permit adequate cleansing and to encourage some bleeding. Most authorities advise against cauterizing the wound. In dealing with bites from animals suspected of having rabies, all factors of the case should be considered and a decision made concerning the administration of antirabies vaccine. When the animal responsible is known to have rabies, or cannot be examined, immediate immunization is indicated. Otherwise, a veterinarian should observe the dog for 14 days. If the dog was infective at the time of the bite, it will die during this period and immunization of the patient must then be started. However, since rabies due to bites about the face and the neck tends to have a shorter incubation period, it may be advisable in such cases to begin immunization at once and continue it until the animal under observation is pronounced to be noninfective or until a full course of vaccine is given.

Care must be exercised in the administration of vaccine, since the occasional patient (estimated as many as 1 in 3,000) may develop encephalitis or a paralysis from the vaccine alone, and some of these cases are fatal. These vaccine "accidents" usually occur at the latter end of a vaccine course and are usually preceded by constitutional symptoms of hives, lymphadenopathy, nausea and fever. Patients with minor bites are given 1 dose of vaccine daily for 14 days, while those in whom the wounds are extensive, on the face or the neck, or inflicted by a rabid animal are administered 2 doses daily for the first 7 days and thereafter 1 dose daily for at least 7 days. For injection sites the tissues of the anterior abdominal wall and the interscapular region are used alternately. The clinical value of hyperimmune rabies serum in the prophylaxis of human rabies, particularly in conjunction with a course of vaccine following very severe types of exposure, is now being studied.

SNAKEBITES[2,11]

Two principal groups of poisonous snakes are found in the United States—the coral snakes and the pit vipers. A differentiation is essential to make the choice of appropriate therapy for snakebite. The coral snake is found from North Carolina to Florida, in Colorado and in the Southwest. The pit vipers include the copperhead (eastern and south-central United States), the cottonmouth moccasin (Virginia to the Rio Grande), and the several varieties of rattlesnakes which are widely distributed in the United States. Coral snakes seldom attack men unless they are provoked. However, the pit vipers, especially the copperhead, the cottonmouth moccasin and the diamondback rattlers, will strike promiscuously.

The coral snakes inflict inconspicuous fang marks, which later may be entirely obscured by edema. The bite mark of a pit viper is more evident, it may bleed and cause a red, currant-like infiltration about the wound

which spreads along the lymphatics as the venom is carried through them into the circulation. A necrotic ulcer frequently develops locally after the bite of a pit viper, but seldom after that of a coral snake, except through secondary infection.

Snake venom is a complex agent containing a large number of toxic components, some of which act locally and others act on the vital organs after absorption. The principal constituent of coral-snake venom is a neurotoxin which is said to have a special affinity for the cells of the respiratory center, although it also affects cells elsewhere in the cord and the brain. The chief constituents of pit-viper venom are hemorrhagin, cytolysins and thrombokinase. Cytolysins and hemorrhagin dissolve the endothelial cells lining the lymph and the blood vessels, and especially those of the capillary walls. Intravascular thrombosis may result from the action of thrombokinase. Snake venom frequently causes hemolysis.

Symptoms and Signs. CORAL-SNAKE BITE. There is immediate intense burning at the site. Somnolence, prostration, nausea, vomiting, incontinence and paralysis ensue, especially paralysis of the respiratory muscles. Ptosis, diplopia and, ultimately, pupillary dilatation are usual eye symptoms. Terminal phenomena are coma and convulsions, death may occur in a few hours from respiratory failure Prognosis depends upon the amount of venom injected; if it is sublethal, the symptoms may abate rapidly and the patient will recover.

PIT-VIPER BITE. There is intense pain in the wound, which later becomes excruciating and tends to radiate. Weakness, tingling and numbness of the extremities, cold perspiration and a feeling of suffocation are experienced. Generalized urticaria may appear, with intense burning and itching Meanwhile internal or external hemorrhages may occur, sometimes with frank bleeding from the conjunctivae and the lips. Death usually results from circulatory collapse. Because the amount of venom may be lethal, even for the largest individuals, bites from the larger varieties of viper are especially dangerous to persons of small physique, especially children.

Treatment. Hospitalization is required. A tourniquet (cord, handkerchief or belt) is placed by the person administering first aid proximal to the bite, if on an extremity. The tourniquet should be applied only tight enough to occlude venous and lymphatic drainage and released 1 minute every 30 minutes to prevent gangrene. The tourniquet is reapplied each time farther up the limb if the swelling progresses. It is essential to prevent exertion, to reassure the patient, to prohibit alcoholic beverages and to order complete rest in bed. Cruciform incisions are made over the bite, each at least 1 cm. long and 0.5 cm. deep. The wound is flushed with saline solution to help in removing the venom. Suction is then applied, preferably with a good vacuum rubber bulb pump, for 30 minutes, and then repeated every 20 minutes out of every hour as long as is necessary. As the swelling progresses, further crucial incisions about 1 inch apart should be made and suction applied.

As for any potentially infected wound, penicillin is given, usually in 300,000 unit intramuscular dosages twice daily. Tetanus immunization is also advised.

No antivenom for coral-snake bite is available. However, antivenin for

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becomes more difficult. Convulsions, delirium and coma may supervene before death occurs from exhaustion

In patients under 5 years of age, fatalities are frequent. Adults usually recover.

Treatment. A 2 per cent procaine solution infiltrated locally will relieve the pain. Supportive measures as for snakebite poisoning may be indicated, however, no morphine should be given. In the treatment of children especially, an antivenin is indicated and can be procured from the Biological Institute of the Department of Health, Mexico, D. F.

TICK BITES[7]

The wood tick *Dermacentor andersoni* (which also causes Rocky Mountain spotted fever) and the dog tick cause toxic manifestations in man, their venom producing hyperemia and hemorrhage, particularly in the central nervous system. The sites of their attachment may become reddened and indurated, and exhibit petechial hemorrhages. The wood tick may cause "tick paralysis," which occasionally culminates fatally. It is an ascending motor paralysis, and any unexplained motor weakness, particularly in a child, calls for careful search for ticks on the patient's body. The most common sites of attachment are the pubic region, the axillae and especially the back of the neck and the scalp.

Removal of the tick by gentle traction usually causes disappearance of all but major symptoms. The application of oil to the body of the tick interferes with its respiration and facilitates its removal. More severe cases will require appropriate emergency and supportive treatment

When one is going through a region in which ticks are known to abound, certain prophylactic measures should be taken. Boots should be worn and the trouser legs tucked inside the boots Zippered shirts are a further precaution. One should strip once or twice daily and, with the aid of a friend, examine one's self thoroughly in an attempt to locate and remove any ticks which he may have picked up before they become attached. Clothes may be effectively fumigated by putting them in a large container and placing a cup of carbon tetrachloride or carbon disulfide on top of them. The container is closed for a few hours, after which any ticks present will have been killed.

More recently, ticks which give rise to disease have been found on domestic animals, especially dogs. Ticks on these animals should be removed with an instrument and must not be picked off or crushed by the bare fingers.

Tick paralysis and Rocky Mountain spotted fever are strictly medical problems, and the symptomatology, the diagnosis and the treatment will not be discussed in this book.

INSECT BITES AND STINGS[7]

There are many insects whose bite or sting, though of no serious consequence, may cause intense local discomfort. It is now well established that a certain degree of immunity to insect bites may be developed, and some efforts in the production of active immunity have been successful.

Bees, Wasps and Hornets. Stings by these insects usually cause nothing more than local redness, swelling and pain, which rapidly disappear. The discomfort may be reduced by prompt application of compresses of fairly strong ammonium hydroxide or other

pit-viper poisoning is procurable. It is available in a sterile syringe equipped with sterile needle, containing 10 cc., the average initial dose for systemic administration. In addition, an injection of 2 or 3 cc. round the wound is advisable to minimize tissue necrosis; subsequently, similar injections proximal to the wound as the tourniquet is shifted also may be advisable. After adequate doses of the serum have been injected, the tourniquet can be removed. For systemic treatment, the dosage and the route of administration will depend upon the age, the size and the clinical condition of the patient. If the patient is a child, or in shock, intravenous administration may be indicated, provided the patient is known or has been demonstrated beyond doubt not to be allergic to horse serum. Otherwise, intramuscular injections are to be preferred. Children may require the same or a greater dosage than adults because the concentration of venom in their bodies may be proportionally larger. The injections of 10 cc. are repeated every 1 to 3 hours until symptoms are diminished significantly; they should be continued at the same rate as long as the swelling, the paralysis or other symptoms are progressing. The doses are gradually reduced in frequency and amount according to the patient's clinical improvement: a total of 50 or 100 cc. of antivenom may be required.

Supportive therapy consists of mild sedation with barbiturates. To combat collapse, 5 per cent dextrose in saline and either whole blood, serum albumin or plasma expander should be given. In every instance the patient should be left under close observation for at least 24 hours, or relapse may occur. In coral-snake poisoning, artificial respiration, perhaps a respirator, may be necessary.

In addition to the standard treatment of tourniquet application, incision and suction of fang wounds, antivenin, tetanus antitoxin and other symptomatic and supportive therapy, Hoback and Green administered cortisone or corticotropin therapy with reported pronounced decrease in morbidity. They believe that these preparations are valuable adjuvants in the treatment of snakebite poisoning.

SCORPION STINGS[7]

The bites of several varieties of scorpions in the Southwest are dangerous, and the severity of the symptoms depends largely on the age and the size of the victim. Among the toxins in the venom are neurotoxin, cardiac toxins and agglutinins.

Symptoms. Locally, the symptoms consist of intense pain, numbness and weakness of the affected limb, and lymphangitis and lymphadenitis proximal to the wound. The systemic symptoms simulate those of morphine poisoning. The patient becomes very anxious and restless, and co-operates poorly. There are salivation, nausea and vomiting. Involuntary urination and defecation may occur. Epigastric and periumbilical pain sets in, with generalized abdominal rigidity. There is intense thirst, and the patient drinks large quantities of water. Hyperglycemia and glycosuria are present. Some cases show the general picture of shock; variations in the temperature and the pulse depend on whether or not this is present, but the respirations are usually markedly increased. There may be muscular inco-ordination and tonic contractions of the limbs, or paralysis. In fatal cases, cyanosis sets in as respiration

rows, and paying special attention to the sites of predilection. If other members of the household are infected, they must be treated simultaneously to prevent reinfestation. Following the bath, sulfur ointment is the time-honored antiscabetic medicament. The usual formulation is: Precipitated sulfur, 1.0, balsam of Peru, 1.0, and petrolatum to make 100 Gm. The ointment is applied to the entire body from the neck down. A garment with long sleeves and legs (underwear or pajamas) is worn throughout the period of treatment. Another application of the ointment is made on the second, the third and the fourth nights, each time without a bath. The next morning a bath is taken and clean clothes are put on. All clothing and bedclothing that have been used before and after treatment must be boiled, ironed with a hot iron, or dry-cleaned and steam-pressed.

Benzyl benzoate is also effective, with 1 or 2 overnight treatments. However, this remedy carries with it the risk of allergic dermatitis in some patients. More recently, hexachlorocyclohexane has been found to be an efficient scabicide. It is used overnight for 2 consecutive nights, the general rules described above for sulfur ointment being applied. Secondary irritation usually clears up promptly with the use of such preparations as calamine lotion. Any pyoderma or systemic infection can be treated by antibiotics, either bacitracin or neomycin locally or penicillin by the parenteral route.

Pediculi.[3] Both pubic and body or head lice may produce skin lesions which are often infected secondarily by scratching. DDT is now considered the remedy of choice. A powder containing 5 to 10 per cent DDT (dichlorodiphenyltrichloroethane) dusted into the clothing will effectively control louse infestations. For the head, either the hair is dusted with DDT powder or an aerosol bomb containing 3 per cent of the medicament is used, and this is followed by covering the head with a towel for several hours or overnight. The hair is combed carefully to remove nits before it is washed. If any are found, the hair is again dusted. This routine is repeated until no infestation is detected on examination. For crab-louse infection, DDT powder is rubbed into the hairy areas involved and is followed by a complete bath the next day. Treatment is repeated a week later or at weekly intervals, as necessary. One or two treatments are usually sufficient.

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alkaline solutions, or by local infiltration with procaine solution. In some cases, the stinger is left in the wound and must be carefully removed.

Rarely, an allergic type of reaction follows a bee sting. This may be characterized by a host of symptoms such as weakness, nausea, urticaria, edema, labored breathing or collapse. This reaction may be treated by 1 cc. of epinephrine 1:1,000. Some have advocated the use of this drug even in the absence of allergic manifestations. More prolonged relief may be obtained by ephedrine, taken orally in doses of 25 to 100 mg.

Mosquitoes. Though a variety of this insect is the agent in the transmission of yellow fever and malaria, the ordinary mosquito bite is usually of interest only because of the intense local itching which results. In a person with some degree of immunity, a wheal develops and rapidly subsides. *In those with less immunity, or less self-control,* the itching is aggravated by scratching, and the irritation may be followed by secondary infection. Occasionally a hypersensitive individual may develop, in about 6 hours, *extremely painful vesicles at the site of* the bite. These persist for about 36 hours. The surrounding tissue becomes markedly edematous. Benson found it possible to immunize such patients against the severe secondary *reaction by the injection of an antigenic* extract of the mosquito.

Welcome relief from the intense itching of mosquito bites may be obtained by the use of camphorated chloral. This consists of equal parts of camphor and chloral hydrate. When triturated, a liquid results; this may be applied locally undiluted, or, for individuals with very sensitive skins, diluted with a bland oil. Camphorated phenol solution in oil has also been used for the itching.

Chiggers or Jiggers. Chiggers or jiggers are terms applied to a variety of insects which are concomitants of summer outdoor life. They should properly be limited to include only the straw mite and the sand flea. The former is a small mite whose bite produces a small wheal which develops into a vesicle. There is intense itching *and sometimes constitutional symptoms.* This bite occurs primarily in those who come in contact with straw. Sulfur destroys the mite, and the clothing should be disinfected. Itching may be controlled by the local applications mentioned for mosquitoes.

Bathers are frequently troubled by swollen itching areas without apparent breaks in the skin. These lesions are due to the sand flea. The female burrows into the skin to deposit her eggs and then dies. *The insect should* be removed by a sterile scalpel or needle after preliminary application of a disinfectant to the skin.

Scabies.[12] Scabies is an infestation with the itch mite, *Sarcoptes scabiei. The female produces a double punctate* lesion as she burrows into the skin to lay her eggs. The tortuous burrow is slightly elevated at one end and has a yellowish-gray dot at the other. The characteristic distribution of the *lesion is in the folds of the skin round* the fingers, the toes, the axilla and the external genitals. The primary eruption may be altered by scratching and secondary infection.

Treatment is entirely external. The patient first takes a thorough hot bath, soaking thoroughly, scrubbing with soap and water, using a washcloth or a soft brush to open the bur-

.9.

Open Wounds

PRINCIPLES OF WOUND CARE

In the care of the open traumatic wound, it must be remembered that healing takes place according to natural processes of tissue repair. It is almost impossible to stop these processes, and very little help is required from the surgeon. So far as the actual treatment of the wound is concerned, all that can be done is to give nature a chance. There are, however, certain conditions which permit nature to carry on with less interruption or with less difficulty. With this in mind, we may consider the treatment of open wounds under two chief headings. (1) the removal or the prevention of factors that hinder healing, and (2) procedures that favor or aid the natural reparative processes.

REMOVAL OR PREVENTION OF FACTORS THAT HINDER HEALING

Healing may be prevented or delayed in an open wound by any one or several of the following: (1) the presence of foreign bodies or contaminating bacteria in the wound, (2) the presence of nonviable tissues in the wound, and (3) continued trauma to the wound or the introduction of additional bacteria into it.

Removel of Bacteria and Foreign Bodies. Every accidental wound contains some bacteria; these may be a definite hindrance to wound repair At first, however, they lie on the tissue surfaces and in the tissue spaces They have not become acclimated to their new environment and, for a period of at least 6 to 8 hours, they do not proliferate or invade tissue. During this time the wound may be considered to be contaminated but not infected. If appropriate treatment can be given, the wound may be rendered sterile or sufficiently so to permit healing to proceed normally without interruption. This is why early treatment of open wounds is important.

Foreign bodies in a wound are also to be looked upon as hindering the normal process of wound repair. These may be driven into the wound at the time of injury, as, for instance, splinters, dust, grease or soil; or they may be due to the injury, that is, clots of blood. The early removal of these foreign materials permits wound repair to take place normally without interference.

Removal of bacteria during the stage of contamination and of foreign bodies is best accomplished by mechanical means. With the wound protected by sterile gauze, the surrounding area, for a distance of at least 6 cm., is carefully cleansed with pHisoHex (a detergent giving a soaplike lather and hexachlorophene) or Septisol (a soapy solution containing hexachlorophene) and water. Hairy parts should be shaved, or at least the hair should be cut away to expose the wound and its area without difficulty. Grease and other such contaminants

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FIG. 91. (*Left*) Lacerated wound of the ear The wound extended through the skin and the cartilage It was treated by simple soap and water cleansing and suture of cartilage and skin with fine wire sutures 2 hours after injury. (*Right*) Primary union, result 5 weeks after suture

this protection should be continued with appropriate sterile dressings [1]

PROCEDURES THAT FAVOR WOUND HEALING AND AID NORMAL REPARATIVE PROCESSES

Hemostasis. Having removed or prevented factors that hinder healing, attention may now be directed toward carrying out those procedures which favor the normal processes of repair Of these, hemostasis is the first to be considered. Wounds heal kindly when they are directly approximated. The presence of shed blood in the wound, however, separates its surfaces, interferes with the blood supply by producing tension and acts as a foreign body, and also is an excellent culture medium for bacteria. The prevention of bleeding in the wound, however, does not mean that all tiny vessels must be ligated The introduction of additional foreign bodies by ligatures and of necrotic tissue produced by ligation is often a hindrance rather than a help in wound repair. Control of bleeding may be accomplished by careful ligation of bleeding points, in which only the vessel itself is ligated with a very slight amount of the tissue surrounding it. Large stumps of ligated material should be avoided. Other small bleeding points in the subcutaneous tissues, muscles and skin may easily be controlled by pressure, either from the approximating sutures or from the pressure dressing. When ligatures are to be used, the finest type of ligature should be employed. Fine silk or cotton probably causes the least reaction in wounds; if catgut is to be used, the finest of fine

should be removed with benzene, carbon tetrachloride or ether. For practical purposes, the type of soap does not make any difference, nor does the water which is used. The important thing is to make the area round the wound mechanically clean by using enough soap and water and scrubbing sufficiently. After the skin area surrounding the wound has been cleansed, the same vigorous mechanical treatment should be given the wound itself. Generous quantities of soap and water should be used, every corner of the wound should be reached, if necessary by use of an irrigating syringe or an irrigating stand and vessel. If the wound is in an extremity, bleeding during this time may be controlled by the use of a tourniquet. Pain may be controlled by local anesthesia injected round the wound after preparing the surrounding skin and before cleansing the wound proper. Fritz and Tanner[2] have suggested the introduction into the wound of gauze soaked in a 5 per cent solution of procaine, to be held in place while the surrounding area is being prepared. This produces a relative anesthesia in a period of 5 to 8 minutes and permits the irrigation and the cleansing of the wound proper without much discomfort. They have found the area of effective anesthesia to extend about 1 cm. beyond the wound edges. The author has used this method with excellent results.

Antiseptics are not used in the effort to remove contaminating bacteria from a wound. Any antiseptic capable of killing organisms also kills tissue, a factor which should not be added when tissues are already devitalized. The highly colored antiseptics are especially bad because they mask the color and the condition of the tissues.[3-7]

Removal of Nonviable Tissues. Tissues which are damaged beyond repair are a definite hindrance to the normal reparative processes and must be removed. In doing so, it should be remembered that the tissues having the poorest blood supply, that is, fascia, tendons and especially fat, are those which are most easily damaged by trauma and have the poorest natural resistance to infection. These tissues should be excised if there is the slightest doubt as to their viability. Muscle and especially skin may be treated with much more conservatism. The treatment of skin flaps requires most careful judgment. Excision is required if the skin is contused beyond repair. However, if there is still a blood supply sufficient to permit the flap to live, it should be conserved. Bleeding from the cut edge of the skin is an indication of a sufficient blood supply and, therefore, an indication for conservatism.[4]

Prevention of Trauma to Wound. Movement of the injured part and the introduction of additional bacteria through the use of soiled handkerchiefs as dressings are factors that are little thought of, but they are extremely important in the treatment of open wounds. The first-aid treatment should be simple adequate splinting of the part and the covering of the wound with a dry sterile bandage tied snugly enough to control hemorrhage; that is all. The most virulent organisms that commonly infect wounds come from the nose and the throat or from the hands of the patient or his attendants. For this reason, the wound should be protected as early as possible with a sterile covering or at least a clean one. After definitive surgery,

swelling is by elevation. This is a most effective therapeutic agent, especially during the first 24 or 48 hours after the primary treatment of the wound. It is most applicable to wounds in the extremities and may be accomplished in the arm by slings, but in the lower extremities bed rest with pillow elevation is necessary.

Infrequent Dressings. Having adequately cleansed the wound, removed devitalized tissue and obtained an adequate wound closure, it is essential not to disturb the wound. Infrequent dressings "limit the chances of secondary infection and the probability of stirring up infection in the wound."[5] Removal of the dressings for simple inspection of the wound may satisfy the surgeon's curiosity, but it serves no useful purpose; all it does is open the sealed wound and start oozing. As a matter of fact, the blood-stained dried dressing on the wound surface often serves as a most effective wound splint. Dressings should be changed only of necessity; if they are soiled, the outermost layers may be removed and replaced without disturbing those next to the wound. If pain, tenderness and elevation in temperature are present, the wound should be inspected for evidences of infection. Otherwise, it should be left alone until it is dressed for the removal of stitches. This may not be necessary for from 7 to 10 days, or even longer. In many instances it may be wise to remove only part of the sutures, leaving the remaining ones until a subsequent dressing In some cases, especially in wounds over flexor surfaces, continued support to the approximated skin edges may be obtained by the application of flamed adhesive strips across the wound after removal of the sutures.

In many traumatic wounds there may be a mild inflammatory reaction, indicated by some redness and edema in the wound tissues. This may well be treated conservatively by the application of alcohol compresses or dressings. Gauze soaked in alcohol is applied over the wound at the time the sutures are removed; for a day or two thereafter the dressings may be moistened with alcohol by the patient at intervals. In most cases the inflammatory reaction subsides readily with this therapy.

CHEMOTHERAPY, PENICILLIN AND SERUM TREATMENT

There are three organisms which are most to be feared as invaders in traumatic wounds; these are the staphylococcus, the streptococcus and the tetanus bacillus. It is recognized that infections by the streptococcus can be well controlled in the invasive state by the use of penicillin. One of the slowly absorbed penicillin preparations given by intramuscular injection every other day for 3 or 4 doses usually gives an adequate protection. As a rule, a dose of 300,000 units is employed.

The tetanus organism is found most often in pucture wounds or contused wounds contaminated with street dust or soil. In simple incised wounds which can be laid open, there is less likelihood of infection from this organism. The intramuscular injection of 1,500 units of tetanus antitoxin is the approved prophylactic treatment against tetanus infection. It should be used in all cases of puncture wounds and contaminated contused wounds and in others in which there is any suspicion or question of the presence of the tetanus bacillus as an infective organism. All that is necessary for pa-

chromic or plain ligatures are the best.

Repair of Injured Tissues. This is performed after cleansing the wound and producing hemostasis. This has as its object the replacement of the injured tissues as nearly as possible in their normal relationship (Fig. 91). If appropriate treatment has been given during the stage of contamination, the repair of injured tendons and nerves at the time of the primary treatment is not only permissible but advisable.

Closure of the Wound. There are two principles which must be kept in mind regarding wound closure: dead space should be obliterated and tension should be avoided To obliterate dead space, a few deep sutures tied without tension approximate tissue and prevent the accumulation of serum in the wound Fine silk sutures are probably the best for this purpose. In wounds that are not too deep, the necessity for buried sutures is less because the approximating sutures in the skin may be sufficient to accomplish this purpose Tension in the wound closure is to be avoided because it interferes with the blood supply of the injured tissues Following trauma, there is always a certain amount of hemorrhage and edema in the tissues which, in addition to tightly tied approximating sutures, may be sufficient to block the capillary flow in the damaged tissues If at all possible, skin closure should be obtained at the time of primary treatment. In wounds with little or no loss of surface tissue, approximation may be accomplished with interrupted sutures, materials which cause little or no reaction in the tissues being used. The fine alloy-steel wire has proven to be excellent in our hands; fine silk or cotton sutures are good also If closure of the wound produces ischemic tension upon the wound edges, relaxing incisions may be indicated or primary skin grafts may be applied In instances in which primary suture of the skin will produce too much tension, it is wiser to leave the wound open or to suture a detached skin flap only partially; the remaining wound may be covered with epithelium by skin grafts, either at the time of the primary treatment or at a later date.

Immobilization of the Part. This essential aid to wound healing has long been recognized but much neglected. Usually, adequate rest cannot be obtained by simple bandaging; the use of splints, either wooden or plaster, may be necessary in wounds in the extremities. In injuries in the lower extremities, bed rest or the use of crutches in addition to the splint is often advisable.

Maintenance of Adequate Blood Supply. A normal or an adequate blood supply is essential to wound healing. The chief factors which prevent this blood supply are swelling and edema in the tissues and other forms of tissue tension The use of loosely tied interrupted sutures in wound closure has been mentioned as a method of preventing tissue tension and permitting the escape of fluids which accumulate in the wound spaces. However, the most damaging type of tissue tension occurs from the post-traumatic edema This can best be prevented by the application of snug dressings which exert a sufficient amount of pressure to prevent congestion Elastic pressure by rubber sponges or mechanics' waste is of value in many cases; this may be maintained by adequate bandages. A further method of preventing tissue

siderable tissue loss, primary closure of the wound is difficult unless relaxing incisions or skin grafts are employed.

Puncture Wounds. A puncture wound is one that is made with a sharp-pointed instrument, such as an ice pick, a knife blade or a nail. Depending upon the instrument, there is the possibility that foreign material and bacteria have been introduced into the wound. Should foreign bodies and soil have been carried into the tissues, it is wise to incise the wound through the point of puncture under local anesthesia. Simple probing of these wounds is to be condemned; nothing can be gained by such a procedure, and often new injuries are produced or new bacteria are introduced into the tissues. When the wound has been incised, the traumatized area may be excised and the wound sutured. When the instrument which produced the puncture is relatively clean, as is a knife blade, it is frequently better surgical judgment to leave the wound alone and watch it carefully for signs of infection. If at any time there appears to be an inflammatory reaction in the area of the puncture, incision is indicated. It is in these wounds especially that tetanus antitoxin must be given. Gunshot injuries by bullet or shot produce puncture wounds in which bits of foreign material, such as clothing, often are carried in with the missile. The treatment of gunshot injuries demands considerable surgical judgment. As a rule, an effort is made to localize the foreign body (see p. 168). Should there be a wound of entrance and a wound of exit, the supposition is that it has passed through the tissues. In some cases of small bullets, it may be wise to treat the lesion conservatively with immobilization and appropriate moist dressings without exploring the wound. In the case of larger bullets, open operation with debridement and removal of the foreign body are indicated, depending upon the position and the amount of destruction caused by the bullet. In most cases of larger bullets, hospital admission is indicated.

Abrasions and Brush Burns. These are superficial wounds caused by friction, as for instance in falls in which the skin is rubbed against the surface of the ground. Very frequently, foreign bodies are ground into the skin surface. These are among the most common and, at the same time, the most poorly treated of all superficial wounds. They demand the same care as any other wound. The most important part of the treatment is the cleansing of the area; this may be relatively painless if compresses of 5 per cent procaine are applied over the areas of abrasion while the surrounding areas of skin are being cleansed. The abrasion is then scrubbed carefully with soap and water, and, if necessary, a sterile brush or the tip of a scalpel is used completely to remove the foreign bodies which have been ground into the skin. It is essential that this cleansing be performed thoroughly at the time of the primary treatment, to leave foreign materials in the skin means later pigmentation and disfigurement. This is especially important in abrasions on the exposed areas of the body such as the hands, the arms and the face. After thorough cleansing, the area may be dressed in one of two ways:

1. An attempt may be made to form an eschar over the area of abrasion by painting it with 1 per cent gentian

tients who have been immunized by tetanus toxin-antitoxin (toxoid) is a booster dose of toxoid There is evidence that a protective immunity lasts as long as 5 years following the last immunization by toxoid, and that the titre of antitoxin in the blood rapidly rises (3-4 days) when toxoid is again given. (See p. 111.)

TREATMENT OF SPECIFIC TYPES OF WOUNDS

Incised Wounds. Incised wounds are those which are made with sharp instruments or objects, such as a knife, a razor or a glass. Little tissue has been damaged or destroyed, and kindly healing may be expected if the care of the wound has been carried out faithfully. These wounds heal with minimal scarring, as a rule, tetanus antitoxin is not necessary in their prophylactic treatment. In many cases of superficial incised wounds, there may be no necessity even for suturing; after the primary cleansing of the injured part, the wound edges may be approximated with flamed adhesive.

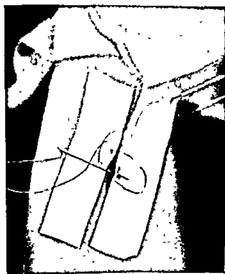


Fig 92 Wound suture without pain by sewing through adhesive strips attached to the lips of the wound.

Gosis[3] has reported a method of closing incised wounds without pain by the simple expedient of suturing adhesive applied to the lips of the wound rather than to the wound tissue itself (Fig. 92). This gives an excellent approximation and has been used by the author in numerous instances In this method of closure, the adhesive should be wide enough to permit a good grasp of the tissues surrounding the wound; an application of tincture of benzoin to the skin, permitting it to dry before applying the adhesive, allows a firmer grasp of the tissues.

Lacerated Wounds. Lacerated wounds are those in which the edges are jagged and irregular. They are produced by relatively sharp objects, such as projecting nails, tin cans, glass and so forth, and imply the use of force in their production. In these wounds there is likelihood of foreign-body inclusion, and there is much tissue destruction by the injuring force. The principles outlined for the care of an open wound apply especially to these injuries. Usually, there is little necessity for the excision of much tissue, and the wound edges can be approximated easily.

Contused Wounds. A contused wound is one which is produced by blunt force, such as that received in falling or in an automobile accident. Usually, there is an associated laceration. Blunt force produces a crushing and a destruction of tissue; therefore, a wider and a more careful débridement is necessary than in the other types of wounds. Since there is con-

during the subsequent days. Numerous local applications have been suggested and used in the treatment of such burns. Tannic acid and other eschar producing drugs fell into disfavor in wartime experience with burns. This occurred for various reasons, but chiefly because better results could be obtained by other local applications McClure and Lam,[8] in a study of 5,609 industrial burns, concluded that for minor burns the best results could be obtained by the following treatment:

1. Wash the area with white soap and water.
2. Do not break blisters or otherwise débride the wound.
3. Cover with fine mesh gauze impregnated with petrolatum
4. Apply over this a firm dressing bulky enough to keep dirt away from the injury but not too large to keep the man off his job.

This treatment is probably as satisfactory as any. Whether or not blisters should be broken is a minor debatable question, since blisters will usually break anyway if a firm pressure dressing is applied, and the protection afforded by an intact blister is questionable, since bacteria invade it from surrounding skin. In addition, many blisters are already broken by the time the patient reaches the surgeon for treatment.

The important points in the care of a burn are:

1. To do all that is necessary in the way of cleansing and preventing infection at the primary dressing.
2. Not to re-dress the burned area, except to change the outside dressings, until the burn is healed, unless, of course, there are complications, i.e., infection.

The importance of not dressing a burn for from 10 to 14 days cannot be too strongly stressed. If the primary dressing has been adequate, most second-degree burns will be entirely healed when the dressing is removed.

Treatment of Third Degree Burns

In third degree burns there is a definite destruction of tissue involving not only the skin but possibly also the underlying tissues. If these are small in area, the patient can be kept ambulatory, but in the case of third-degree burns of any extent hospitalization is recommended. In the local treatment of these areas, the preparations described for second-degree burns are used and the principles of treatment are the same No effort is made to excise the burned areas When the burn is first dressed on the tenth to the fourteenth day, the destroyed tissue can be lifted off with forceps and scissors. An ulcer with a granulating tissue base remains; this must heal, either by secondary intent or by skin grafting. The latter method definitely is preferable and, as soon as clean granulations are formed, either a Thiersch or a Reverdin skin graft may be used to hasten the epithelization. Pinch grafts may be used for ambulatory patients if the part on which the graft is to be placed can be immobilized by splinting.

In prophylaxis of infection, penicillin may be given. The staphylococcus and the streptococcus are the usual infecting organisms, and both usually are controlled by this antibiotic. The broad-spectrum antibiotics may also be used.

Later Treatment of Burns

Frequently, one sees patients with severe burns who have been discharged from hospital care before the burned area was healed Often these

serious aspects of burns — the shock, hemoconcentration and other serious disturbances of fluid balance—are not complications which can well be taken care of in the ambulatory patient.

First-aid Treatment of Burns

The first-aid treatment depends somewhat upon the extent, the location and the degree of burn. In first- or second-degree burns, almost any form of treatment which combines protection of the lesion with relief of pain will give good results In more extensive burns of second or third degree, however, primary treatment is of particular importance because it may influence the ease with which subsequent treatment may be given. Most burns, by their very mode of causation, are primarily sterile. If the entire epiderm is not destroyed, they will heal rapidly if infection does not enter the picture. The organisms that cause troublesome infections are most often those from the nose, the throat and the hands of the patient himself or his attendant, hence the importance of an early protective dressing. A thorough washing with soap and water followed by a simple petrolatum dressing applied with firm pressure is probably all that need be done in most minor burns. In more extensive burns, in which there is an associated shock, hemoconcentration and other physiologic disturbances, hospitalization is necessary. In such cases, first aid consists of the application of a simple protective dressing and of relief of pain by morphine, leaving the definitive treatment for the better facilities afforded by the hospital.

Treatment of First-Degree Burns

In first-degree burns the tissue damage is minimal, there is an erythema resulting from superficial capillary dilatation, also capillary changes of mild degree in the outer layers of the skin in which transudations and effusion have not developed. These burns result mostly from hot fluids or from exposure to sunlight or an ultraviolet lamp. When they involve a considerable surface of the body, they give marked pain and may produce systemic symptoms, nausea, vomiting, headache and malaise. As a rule, however, patients recover within 24 to 18 hours without marked systemic disturbances. Various antiseptic and anesthetic ointments have been recommended and used for years. The oily ointments which exclude the air from the burned area give considerable relief. It is questionable whether the anesthetic incorporated in the ointment is of any particular value.

Many relatively serious sunburns have resulted from exposure at the seashore. Mitchiner[9] gives a prescription which he found beneficial in territorial camps:

℞:	Calomine	100 gr.
	Zinc oxide	400 gr.
	Tannic acid	100 gr.
	Glycerin	1 oz.
	Water	1 pint

This lotion is applied at hourly intervals until irritation is relieved, the lotion itself has a pleasant tanning effect on the skin.

Treatment of Second-Degree Burns

In second-degree burns there is a more marked local tissue disturbance with capillary wall destruction resulting in edema and bleb formation These burns are by far the most frequent in number. They may result from scalds, from flame or the touching of hot objects When seen by physicians, usually numerous blebs have formed, but others may form

during the subsequent days. Numerous local applications have been suggested and used in the treatment of such burns. Tannic acid and other eschar-producing drugs fell into disfavor in wartime experience with burns. This occurred for various reasons, but chiefly because better results could be obtained by other local applications. McClure and Lam,[8] in a study of 5,609 industrial burns, concluded that for minor burns the best results could be obtained by the following treatment:

1. Wash the area with white soap and water.

2. Do not break blisters or otherwise débride the wound.

3. Cover with fine mesh gauze impregnated with petrolatum

4. Apply over this a firm dressing bulky enough to keep dirt away from the injury but not too large to keep the man off his job.

This treatment is probably as satisfactory as any. Whether or not blisters should be broken is a minor debatable question, since blisters will usually break anyway if a firm pressure dressing is applied, and the protection afforded by an intact blister is questionable, since bacteria invade it from surrounding skin. In addition, many blisters are already broken by the time the patient reaches the surgeon for treatment.

The important points in the care of a burn are·

1. To do all that is necessary in the way of cleansing and preventing infection at the primary dressing.

2. Not to re-dress the burned area, except to change the outside dressings, until the burn is healed, unless, of course, there are complications, i e., infection.

The importance of not dressing a burn for from 10 to 14 days cannot be too strongly stressed If the primary dressing has been adequate, most second-degree burns will be entirely healed when the dressing is removed.

Treatment of Third-Degree Burns

In third degree burns there is a definite destruction of tissue involving not only the skin but possibly also the underlying tissues. If these are small in area, the patient can be kept ambulatory, but in the case of third-degree burns of any extent hospitalization is recommended. In the local treatment of these areas, the preparations described for second-degree burns are used and the principles of treatment are the same No effort is made to excise the burned areas. When the burn is first dressed on the tenth to the fourteenth day, the destroyed tissue can be lifted off with forceps and scissors. An ulcer with a granulating tissue base remains; this must heal, either by secondary intent or by skin grafting. The latter method definitely is preferable and, as soon as clean granulations are formed, either a Thiersch or a Reverdin skin graft may be used to hasten the epithelization Pinch grafts may be used for ambulatory patients if the part on which the graft is to be placed can be immobilized by splinting.

In prophylaxis of infection, penicillin may be given. The staphylococcus and the streptococcus are the usual infecting organisms, and both usually are controlled by this antibiotic. The broad-spectrum antibiotics may also be used.

Later Treatment of Burns

Frequently, one sees patients with severe burns who have been discharged from hospital care before the burned area was healed. Often these

patients are given ambulatory treatment and frequently are neglected. As a result, the granulation tissue in the area of third-degree burns becomes hypertrophic and, instead of appearing as a bright-red, easily bleeding surface, becomes a gelatinous, grayish, unhealthy overgrowth. Healing is very much delayed by this excessive granulation, and the deposition of excessive fibrous tissue produces hypertrophy and unsightly scars, which later may give definite contracture.

The therapeutic indication is to cover the area as soon as possible with epithelium. Growing in from the sides, the epithelium covers the granulating area with great difficulty; therefore, nature must be given some aid. The most effective and the most rapid method is by the application of skin grafts, but, before this can be done, it is necessary to remove the excessive granulation, either by actually cutting it away with a razor, scissors or a knife or by removing it with caustic chemicals, such as silver nitrate stick. With the former method, there is usually considerable oozing, which is easily taken care of by pressure; with the latter method, the oozing is usually not so great, but grafts cannot be applied until a day or two later, when the effects of the silver nitrate have disappeared. Occasionally, the same result may be obtained by the use of pressure dressings over the area of hypertrophied granulation. When the granulating area is smooth and even with the surface of the surrounding skin, the epithelium from the sides grows in more rapidly and skin grafts are more likely to "take."

One should not forget the shock, the weakness and the anemia which frequently follow a severe burn. Attention to the patient's general health is worth while; it helps the local area to heal. A high vitamin and high caloric diet, fresh air, sunlight and other such measures of good hygiene should be taken into account in caring for these patients.

Special Burns

Burns of the Face from Explosions. Burns of first and second degree from explosions are not uncommon in the face. There is frequently singeing of hair, eyebrows and eyelashes, and occasionally blistering, but the burns are not usually serious or deep. However, because of the thin skin over the ears and on the eyelids, even "flash" burns may be of third degree. The treatment of burns of the face is the same as that indicated for those of second and third degree. The problem is one of applying a firm pressure dressing and still permitting the patient to see, breathe and eat. This is accomplished by bandaging the dressings in place and cutting them away from the mouth, the nose and the eyes. A drop of sterile mineral oil is instilled into each eye twice daily, and the secretions that glue the lids together may be removed with swabs moistened in sterile saline solution.

Burns of Hands and Feet. In burns of hands and feet, sterile gauze should be placed between the digits A compression dressing may be applied by using sterile, fluffed gauze or mechanics' waste to pad the irregularities of the surface Two-inch elastic bandage or snug gauze bandage should be used to provide pressure.[11]

Chemical Burns. Chemical burns are often seen in employees of industrial plants and elsewhere. The type of tissue destruction which occurs is

similar to that which is seen in scalds, except that the action of the burning substance is more prolonged. The best method of treatment is a simple dilution of the chemical by using generous quantities of water. This form of treatment is much preferred to attempts to neutralize the action of the chemical. The latter procedure may not only be ineffective but cause considerable harm by producing further heat at the site of the interaction of the two chemicals. Generous quantities of water will so dilute the chemical not already combined with the tissues as to prevent its further action. Subsequent treatment of the burned area is similar to that described for burning due to heat.

Electrical Burns. Electrical burns are usually of such serious nature that the patient cannot be kept ambulatory. They result from the passage of the electric current through the body, and, although the apparent area of burning may be relatively small, the intense heat generated produces a charring at the point of contact which extends deeply into the tissues, frequently destroying tendons, muscles and blood vessels. These patients should be sent immediately to the hospital for care.

FROSTBITE

Etiology. Frostbite is a form of peripheral vascular disease due to the fact that cold produces peripheral vascular changes which cause the typical symptoms and lesions. There are numerous predisposing factors which may account for the occurrence of frostbite. It is easy to understand how patients with peripheral arterial disease, such as endarteritis, arteriosclerosis or diabetes, and with circulatory incompetence, as in myocarditis or debility, may develop tissue changes earlier than patients with a normal peripheral circulation. The wind velocity is also a factor, as has been pointed out by Brahdy.[2] The loss of heat produced by the motion of the surrounding air predisposes to the development of frostbite. Another factor of importance is previous frostbite; areas once subjected to it are more readily susceptible to subsequent exposure to cold. Moisture is also a factor which predisposes to frostbite. Wet clothing, especially wet shoes and socks, permits chilling by conduction, which is a more rapid and effective application of cold than is chilling by cold air alone through the process of radiation. During World War II, three types of frostbite were seen—in aviators in high-altitude flying, in shipwrecked sailors who developed what was called "immersion foot,"[3,4,6] and in foot soldiers exposed to wet and cold, "trench foot."

Course. On exposure to cold, the capillary bed and vessels of the exposed parts dilate and produce an active hyperemia. Continued exposure produces a vasoconstriction with, first cyanosis and then a blanching of the part due to ischemia. If the application of cold is continued, an actual gangrene may develop due to the prolonged ischemia and anoxia.

Symptoms. The history given by the patient is usually quite characteristic. After exposure to cold, the patient notices in hands, feet, ears or nose at first a sticking, burning sensation and then a definite numbness or anesthesia. The part of the body involved becomes wax-white in color. The numbness should be a warning that further exposure to cold is dan-

gerous. If the patient goes into a warm room, the ischemic area becomes intensely red and edematous and is associated with an itching and tingling sensation. Chilblains may form, these are nodular swellings surrounded by a reddened area of hyperemia or cyanotic flat swellings in the area exposed. Chilblains cause symptoms long after the exposure to cold is over. They are characterized by a painful, tingling sensation, which is aggravated when the part becomes warm. In this stage, complete recovery may follow if the exposure has been short duration.

If the exposure to cold is continued after numbness appears, more marked tissue changes occur. When the exposure is terminated and the part is warmed, vesicles and blebs form over the exposed part with marked swelling of the soft tissues and a burning, painful sensation. Prolonged exposure or exposure to marked degrees of cold produces death of the tissues and gangrene.

Treatment.[5,12,13] Although for years it has been taught that friction with snow on the areas of frostbite is the accepted method of treatment, there is no clinical or experimental evidence to support this therapy. Dry warmth seems to be the most effective treatment, and this is easily obtained by placing the frostbitten parts against warm areas of the body in a room of normal temperature. Mild friction may help in permitting the normal resumption of circulation. If blebs have formed, they should be punctured and the part protected with sterile cotton or wool bandaged lightly in place. If areas of cyanosis and anesthesia persist, it is probable that local gangrene will develop.

Conservative therapy is the method of choice in the treatment of peripheral disease due to exposure to cold. If the part can be protected from repeated exposure, frequently an unbelievable recovery takes place. Patients with frostbite of ears, nose or fingers may be kept ambulatory, but those with frostbite of the feet frequently demand hospitalization.

All patients who have been subject to frostbite should be warned against further exposure to cold.

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Foreign Bodies

GENERAL CONSIDERATIONS

Foreign bodies in soft tissues present many problems in the treatment of ambulatory patients.

The first problem is infection in the primary wound. Potentially, almost all foreign bodies are infected, and, because of the small wound of entrance, tetanus bacilli, as well as the common pyogenic organisms, must be considered as likely invaders. It should be a rule, therefore, in the primary treatment of foreign bodies to give tetanus prophylaxis routinely.

The second problem is whether or not to remove the foreign body. When it has recently entered the tissues, is easily localized and is easily accessible, its removal is usually attempted. If, however, no symptoms are produced and removal would entail an operation which might do more harm than the presence of the foreign body in the tissues, it is usually better judgment to let it remain. Many foreign bodies, especially metallic ones, may become encysted by scar tissues and give no symptoms whatever. At any time, however, due to trauma or latent infection, the encysted body may become painful and demand treatment.

When it is decided to remove a foreign body, the problem of locating it in the tissues arises. This may not be difficult if the object can be palpated or it is relatively large and the wound of entrance is plainly visible. When the foreign body is small and deeply located in fat or muscle, its removal is difficult, particularly when it cannot be definitely localized in the tissues with reference to some point on the skin surface. This is especially true of small sharp-pointed objects, such as needles or parts of needles, which may move in the tissues as a result of pressure or the movement of tendons and muscle.

In localizing a foreign body in the soft tissues by roentgenograms, a point on the skin which can later be identified is selected. The wound of entrance, if visible, is usually the point chosen, since it will be easily visible at the time of operation. If, however, the wound of entrance has already healed, some other point on the skin in the region in which the foreign body appears to be located may be selected and marked with silver nitrate. This makes a black stain which will last for several days.

The head half of a pin is placed on the skin with a small piece of adhesive, the head being located at the site of the wound of entrance or on the silver nitrate dot. The part is then immobilized with a splint. Wooden splints are the best, since they are not radiopaque (Fig. 93, *left*). Roentgen films are then made in the anteroposterior and the lateral positions (Fig. 93, *right*). With such films available, the location of the foreign body in relation to the wound of entrance may be definitely determined, its distance

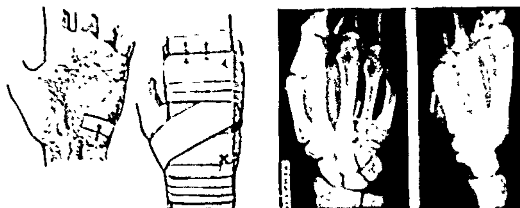


FIG. 93 (*Left*) Localization of foreign body. The head half of a pin is placed on the skin surface with the head lying at the wound of entrance. A splint is applied and the site of the wound entrance marked with an X in ink. (*Right*) Roentgenograms are made, and in the anteroposterior view the site and the direction of the foreign body may be noted in regard to the wound of entrance, while the distance from the skin surface to the foreign body may be seen in the lateral view.

from the skin surface may be seen, and its direction in the tissues may be ascertained. The splint should not be removed while the films are being made; it should be left in place from the time the roentgenogram is made until the time of operation. This is very important, because if movement of the part is permitted, the foreign body may move in the tissues to a different place. Thus, after making a roentgenogram of a foreign body in the foot, the patient should not be permitted to walk before the operation.

The last problem in the care of foreign bodies in the soft tissues concerns the operative removal. As has been mentioned, this is extremely difficult, especially when the foreign body is a small sharp-pointed object lying in muscle or fatty tissue.

There are several important aids which should always be employed.

First, the field should be absolutely bloodless Hemostasis is best obtained by using a tourniquet when the foreign body is in the extremities. When tourniquets cannot be used, local anesthesia with epinephrine aids visualization very materially by keeping the field dry. Tissue tension by retraction also helps to prevent the slight ooze which may come from the capillaries or the veins.

Second, absolute anesthesia is helpful. General anesthesia is usually not necessary in the removal of foreign bodies, but an adequate local anesthesia is imperative. Block anesthesia is often more helpful than local infiltration because no tissue edema is associated with such an anesthetic; on the other hand, in superficial foreign bodies, local infiltration anesthesia can be used without difficulty.

Finally, the proper selection of the incision is important. The incision must be made to permit adequate exposure of the bed and easy removal of the foreign body; also, the underlying tissues must be considered so that the wound will not be made where it will



FIG. 94. Painted wood, which produces a roentgen shadow. This patient was a psychopath who had a draining sinus of the palm The roentgenogram demonstrated numerous splinters, which are shown on the gauze sponge as they were removed at operation.

damage important structures. When possible, the wound is made to cross the axis of the foreign body transversely; this is especially helpful in trying to locate deep foreign bodies in fatty or muscular tissue. If the wound of entrance can be located, it frequently is possible to enlarge it, knowing the direction taken by the foreign body from the roentgen film. In many cases of recent entrance of a foreign body, there may be an area of bloodstain which can be traced to the site of the body in the tissues. The procedure at the time of operation will be discussed in greater detail in connection with the various types of foreign bodies encountered.

TYPES OF FOREIGN BODIES

Wood Splinters. Wood splinters are a very common type of foreign body in the soft tissues; they are found in any part of the body, most frequently in hands, feet and buttocks. Most often, the foreign body is a piece of floor or other board which has been exposed to all sorts of bacterial contamination; therefore, the wounds produced are potentially highly in-

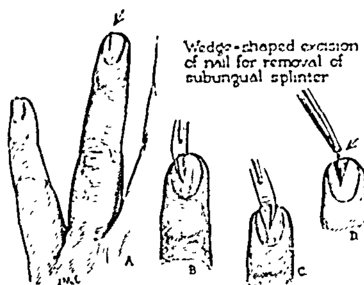


Fig. 95. Excision of nail over a subungual splinter.

fected wounds and the danger of tetanus is especially great. As a rule, the wound of entrance is so large and the pain is so marked that the patient seeks treatment immediately. Roentgen localization is usually not employed, because wood is not radiopaque, unless it happens to have been painted (Fig. 91). Conservative treatment in this type of case is most dangerous. If the foreign body can be removed easily and early and the entire wound excised, the wound can be sutured primarily, and healing with primary union can be expected. If an attempt is made to clip the skin conservatively at the wound of entrance and to pull out the splinter, there is considerable danger that bits of splinter will be left in the wound, with a resulting certainty of prolonged infection.

When a splinter is superficial and lies more or less parallel to the skin surface, it is wise to infiltrate the area round the wound of entrance and along the course of the foreign body with procaine solution. The entire wound of entrance is excised, and, after the skin is divided over the line of the splinter, good retraction is obtained to permit exposure of the entire foreign body in the tissues. Every part of the bed of the splinter should be visible, and the fatty tissues in which it lies should be completely excised. If this comparatively radical procedure is carried out early, the wound may be irrigated with saline and closed primarily with good prospect that primary healing will occur. In this treatment, of course, the use of tetanus toxoid or antitoxin as a prophylactic measure must not be neglected.

Splinters under the fingernail are treated by excision of the nail over the splinter. This can usually be performed without anesthesia, the scalpel being held almost parallel to the nail and a V-shaped area of nail over the splinter excised (Fig. 95). By this method the entire splinter may be removed and an anaerobic wound converted into an aerobic one. A simple finger dressing is all that is necessary until the wound is healed.

Rees* has reported an ingenious

* Rees, Clarance L. The removal of foreign bodies: a modified incision, J A M A 113:35-36, 1939.

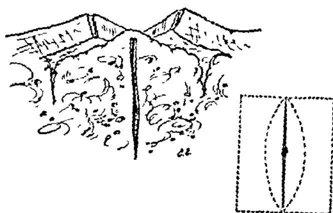


Fig. 96. Removal of foreign body by the method of Rees After an incision through the wound of entrance, an area of skin is undermined and pressure is made on the sides of the wound The fat containing the foreign body thus is made to protrude into the wound. Rees advises removal of the fatty tissue round the foreign body, as well as the foreign body itself.

method for the removal of foreign bodies, such as needles, thorns and splinters, which break off under the dermis at nearly right angles to the surface of the skin. Difficulty in removing such objects is often encountered because the incision may pass on one side or the other of the foreign body, and it is difficult to determine on which side it lies. Rees suggests that incision be made only through the skin and the skin then undercut on all sides for a distance of about ¼ in. In this way, the fatty tissue in which the foreign body lies is not disturbed, and, by pressure upon the sides of the wound, the fat may be extruded into the wound and bear the foreign body with it (Fig. 96). He advises excision of the fat containing the foreign body rather than simply removing the object. When the foreign body projects at the skin surface, he makes an elliptical incision centering on the wound of entrance. The removal of the elliptical piece of skin in the center then shows the exact location of the foreign body, which may be removed as described above (Fig. 97) In such exploration for foreign material, he advises that the local anesthesia be deposited not as an infiltration but as a field block round the area in which the foreign body is

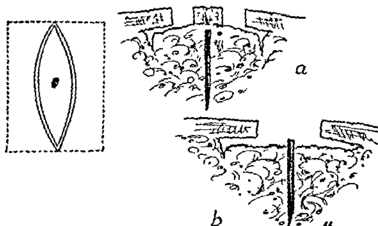


Fig. 97. Removal of contaminated foreign body by the method of Rees First, an elliptical incision is made round the wound of entrance After undermining the wound, the elliptical skin is excised, showing the location of the foreign body in the subcutaneous fatty tissues The foreign body and surrounding fatty tissues are excised, and the wound is sutured primarily.

believed to lie. In this way, the thickening of the tissues by edema is avoided.

Steel Splinters. Steel splinters are frequently seen in those who have been hammering on chisels or other metal objects. Splinters may enter the tissues at any point, and, because of their small size, are often unnoticed by the patient except for a slight sting. Later, some bleeding may be observed, and this calls the patient's attention to the tiny wound. When such a history is obtained, one can be almost certain that there is a small foreign body embedded in the tissues, and a roentgen film will demonstrate it. Metal splinters entering the tissues in this way may be embedded very deeply, and they are especially difficult to find. Furthermore, the heat which is generated by the pounding may render them fairly sterile and the question arises as to the advisability of attempting to remove them. Occasionally, when a splinter lies deeply, it may be better surgical judgment to leave it. on the other hand, if the splinter lies superficially under the skin and its removal is easy, an operation for its extraction should be performed. In this type of foreign body, examination should be made for injuries to important structures, that is, the severing of tendons, nerves and so forth, frequently, though the skin opening is relatively minor, rather serious difficulty may be produced in the deeper tissues.

Cinders, Coal and Stone. Cinders, bits of coal, stone and other similar materials are foreign bodies commonly found in the tissues in accidental wounds, especially in children. Often they are not recognized at the time the primary wound is treated and, as a result, lie embedded in the tissues for a considerable period of time. As a rule, they are not embedded very deeply, but, because of the fact that they carry with them considerable amounts of infective material, they almost always set up local infections. Although the primary wound apparently has been treated adequately, the embedded foreign body produces a chronic draining sinus. This is so common that we have come to suspect that any traumatic wound which continues to drain septic material over a period of time has a foreign body embedded in it. Investigation of such a wound with a needle or other searching object will frequently locate the embedded cinder. When the wound is incised and the foreign material is removed, healing takes place rapidly.

Clothing. Bits of clothing may frequently be foreign bodies. They have the same potentiality for infection as do other foreign materials. A possibility that often is overlooked is that clothing may have become embedded in the tissues.

A case in the author's experience pointed up this lesson very forcefully and taught him the necessity of investigating every wound which continued to drain over long periods of time. A patient en route home from Europe on a cattle boat fell down a ladder and was thrown against the handle of a refrigerator door. He received a rather large puncture wound in the lower sacrum, and, when he landed in this country, he went immediately to a hospital, where the wound was dressed. He later came to our clinic and, because of the position of the draining wound, was thought to have an infected pilonidal cyst. Eventually, he was operated upon for the cyst, and, in the course of the operation, a large piece of trouser ma-

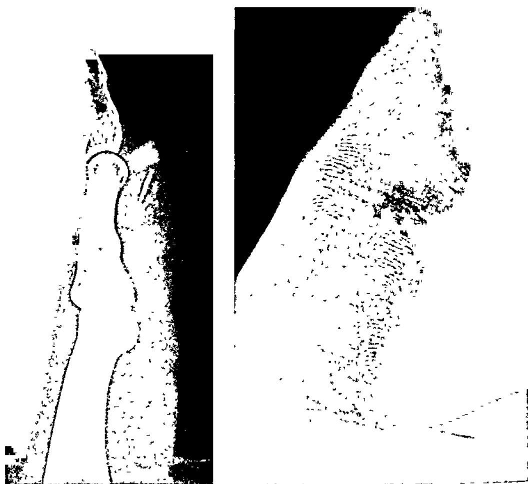


FIG. 98 (*Left*) Roentgenogram showing glass embedded in the finger.
FIG. 99 (*Right*) BB shot which had been in the finger for 1 year. Although no infection appeared, the patient wished to have it removed because of pain on pressure.

terial was removed from the depths of the wound. Healing took place promptly after its removal. In battle injuries, clothing driven into the wounds by shell or grenade fragments was a frequent cause of draining wounds. Prompt healing usually followed removal of the foreign body.

Sutures. In surgical wounds which become infected and from which there is a small draining area, the possibility must be borne in mind that a suture is acting as a foreign body. Silk sutures are the worst offenders, and the next are large catgut knots; occasionally, small pieces of cotton or gauze are found in such wounds. The search for possible sutures may be facilitated by the use of a small crochet hook sterilized and inserted into the wound. It is possible often to catch the offending suture with the hook and draw it out of the wound. Healing then takes place. Here again is another instance

of a chronic draining wound caused by the presence of a foreign body.

Glass. Broken glass is a common foreign body; it is seen most frequently in the hands and the fingers, having occurred from the breaking in the hands of a glass object. In automobile accidents, glass from the shattered windshield may be found anywhere in the body, frequently in the forehead and the face. Finally, glass is often a foreign body in the feet. Difficulties often arise in the diagnosis because the patient does not know whether he simply has been cut by glass or the glass has remained embedded in the tissues. Palpation of the wound frequently gives no indication in this respect. It is usually worth while to have a roentgen film made when embedded glass is suspected; many types of glass will show on the roentgen film (Fig. 98), especially glass from a windshield. When there is uncertainty as to the presence or the absence of glass in the tissues, it usually is wise to treat the wound as a laceration primarily unless the glass can be seen or palpated or demonstrated on the roentgen film. After healing has occurred, glass will make itself evident by the pain produced by pressure upon it; incision can then be made over the painful spot and the glass removed. In operating for the removal of bits of glass from the tissues, absolute hemostasis must be obtained because even at best glass is seen with a great deal of difficulty.

Fish Bones. Fish bones and the bony parts of fins are frequently embedded in the tissues. Potentially they are highly infective, and their removal should be attempted as soon as possible. The danger from such foreign bodies is not only the usual type of infection but also the erysipeloid of Rosenbach. These bodies are radiopaque and can, therefore, be demonstrated on the roentgen film. They usually are not embedded far in the tissues and almost invariably are in the hands or the fingers. Their removal is usually easy because they can be well localized. The Rees method of treatment (see pp. 171-172) is used to advantage here. It is wise not to attempt to suture the wound but to leave it open and treat it as a primary infection.

Needles. Needles or parts of needles of various sorts are common foreign bodies in the hands and the feet. A needle penetrating the hand of the woman washing clothes is a very frequent occurrence, as is the broken sewing needle in the foot. Victrola needles, too, are often seen, mostly in the hands and the fingers.

These foreign bodies are among the most difficult to localize, because they are so small and because, in the feet at least, they are frequently deeply embedded in the fatty adipose tissue. Accurate localization is the secret of their removal. They are best located by an incision which is designed to cross transversely the long axis of the object. Most needles, after they have been in the tissue for any period of time, become oxidized and black and, therefore, are seen fairly easily if the field is bloodless. Recently it has been found that if the incision is made along the line of entrance of the needle, there is frequently a dark-stained area of hemorrhage which can be followed.

We have rarely found it necessary to use the fluoroscope in locating needles in the hands or the feet, where they are most commonly embedded.

The occasional needle embedded in other parts of the body, however, is removed with a great deal of difficulty. One such case in our experience taught us a lesson in attempting to locate small foreign bodies in the fatty tissue of the buttocks. A woman was interrupted in the act of mending her panties. Later she put them on and went out. In sitting down in the street car, the needle entered her buttock and she presented herself to us for its removal In such a case, the fatty tissues of the buttocks are compressed when one sits down and, when the pressure is released by standing, the needle will remain deep in the tissues, the fatty tissues re-forming their rounded contour. A needle in such a location is localized from the surface of the skin with difficulty, and fluoroscopic visualization is a considerable aid in this respect.

Not infrequently hypodermic needles are broken off in the subcutaneous tissues. The danger from this type of foreign body is not great, because most of the needles are sterile when inserted; nevertheless, their removal is usually attempted if it is possible to do this easily. Patients who are diabetic and give themselves their own insulin often break needles in the thigh. These are removed with a great deal of difficulty unless they can be well localized in the soft tissues It may be wiser to leave them in place rather than to attempt their excision.

Bullets. Various types of bullets are often embedded in the tissues. In most cases of shot of very large caliber, the foreign body has progressed so deeply



Fig. 100 Encysted BB shot removed from the middle phalanx. The shot had entered the finger 5 years previously. Swelling gradually reached size as shown above. Inset shows the BB shot and the pseudocyst.



Fig. 101. Foreign body granuloma on the dorsum of the hand. This was thought to be a fibroma, but, on opening the tumor, an encysted splinter was found. The patient then recalled a splinter's having entered the hand many years before.

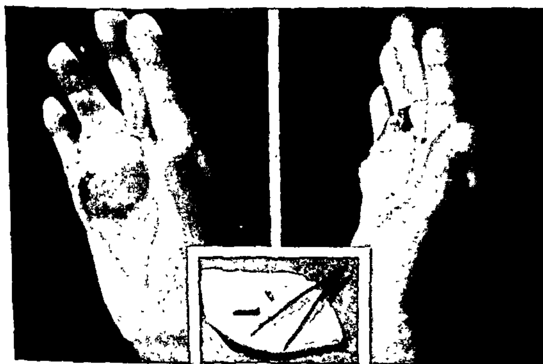


Fig 102 Photograph of foreign body described in the text A small piece of file was removed from an area of spontaneous drainage in the center of the granulomatous mass. The entire process subsided following removal of the foreign body.

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FIG 100. Encysted BB shot removed from the middle phalanx. The shot had entered the finger 5 years previously. Swelling gradually reached size as shown above. Inset shows the BB shot and the pseudocyst

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Superficial Cysts and Tumors

SEBACEOUS CYSTS (WLN)

Etiology. Sebaceous cysts are common examples of a retention type of cyst in which the outlet to the duct is blocked, usually by secretion. the gland continues to secrete, producing a dilatation of the duct and the gland. The cysts are found anywhere on the skin surface but mostly on scalp, face, ear and neck. In 100 sebaceous cysts operated upon, locations were as follows: forehead, 8; scalp, 33; face, 19, ear, 15; neck, 9, breast, 3, arm, 3, back, 5; abdomen, 3, chest, 1; buttocks, 1.

Diagnosis. Very frequently the cysts are multiple (Fig. 103). They may occur at any age, but they are seen most often in adults past midlife. As a rule, they may be diagnosed on simple inspection, but occasionally they have to be differentiated from dermoid cysts. The fact that they are always attached to the skin at the outlet of the duct is a helpful diagnostic point in this respect. Frequently, the duct





Fig. 103 (*Left*) Multiple sebaceous cysts of the scrotum

Fig. 104 (*Right*) Large sebaceous cyst of the scalp.

and has caused so much damage that the patient should be admitted to the hospital for care. On the other hand, small shot (BB or bird shot) may be only superficially embedded in the tissues, and the patient may be ambulant. These foreign bodies are radiopaque, and their localization by roentgen examination is, therefore, comparatively easy. Fortunately, in many cases, the heat generated by the firing of the gun and by the passage of the bullet through the air renders such foreign bodies relatively sterile, so that, when they are inaccessible, their removal may be delayed until it is seen whether or not infection takes place (Fig. 99).

Fishhooks. Fishhooks are occasionally embedded in the soft tissues, usually in the fingers. Because of the barb, their removal is difficult, but this may be accomplished by pushing the point through the remaining portion of the soft tissues, cutting off the barb portion of the hook with pliers and then withdrawing the hook in the direction from which it was inserted. Such wounds can be treated with hot moist dressings until the danger from infection is past.

LATE TREATMENT OF FOREIGN BODIES

Foreign bodies left in the tissues for a considerable period of time may become encysted by fibrous tissue and give no symptoms (Figs. 100 and 101). At times the irritation produced by them causes a granulomatous swelling which may be so hard and firm as to be mistaken for a tumor growth (Fig. 102). One such case occurred in the author's experience. A piece of a file became embedded in the hand of a woman when she was 19 years old; she appeared for treatment when she was 83 because of a swelling of the hand, which was mistakenly diagnosed as a sarcoma. Believing that the sarcoma arose from the bones of the hand, a roentgen examination was made; this disclosed the true state of affairs—the foreign body. Through a small incision in the center of the granulomatous area, the piece of file was removed and the granuloma promptly disappeared. The same reaction from silk sutures in a wound has been seen in a few patients. The knowledge that this type of reaction occurs and that the removal of the foreign body results in prompt healing is useful on occasion.

ence in areas in which pressure may be exerted upon them, as on the scalp Frequently they are complicated by infection. This adds the symptoms of pain and rather rapid enlargement of the cyst area. When infection makes its appearance, the increase in the swelling is due to a rupture of the cyst wall with the formation of a pocket of pus in the area of the cyst The previously present hard or doughy mass now may become definitely fluctuant.

The other complication, which occurs only rarely, is carcinomatous degeneration. When malignant change has taken place, the cyst becomes a hard woody mass, definitely fixed in the tissues, and is usually not at all difficult to diagnose.

Treatment. The treatment of sebaceous cysts is excision. This is indicated both for the prevention of possible infection and for cosmetic reasons. The operation can usually be performed under local anesthesia: the cyst is exposed by a simple incision of the skin over it, and frequently the duct entrance on the skin surface is removed with the cyst. If the cyst is ruptured in its removal, its wall can easily be identified and removed after evacuation of its contents (Fig. 105).

Two variations in the care of sebaceous cysts have been suggested. Their advantage is that suture of the wound is not needed and, therefore, a less formal procedure is necessary. Nicholl,[37] after infiltration round the cyst with procaine solution, makes a stab wound in the cyst and expresses its contents by pressure. The area of the cyst is then kneaded between the thumb and the fingers of the two hands until the edge of the cyst wall protrudes at the stab wound. This is grasped with a toothed forceps or a hemostat, and, with gentle traction and continued kneading, the entire wall of the cyst can usually be delivered A pressure dressing is applied.

Danna[14] suggests a method that is especially good for the care of multiple cysts of the scalp, but of course it may be used wherever multiple cysts are to be treated. A needle is inserted into the most prominent area over the cyst, preferably near the duct opening The tip of the needle should barely protrude into the cyst cavity. A whitish eschar is produced round the needle tip by touching the needle with a diathermy electrode (unipolar current). The very weak current used produces only a momentary stinging sensation, and, as a rule, anesthesia is not necessary. In 5 to 8 days a button of necrotic skin comes away, leaving a large opening into the cyst cavity. "In the course of the next 3 to 6 weeks, the cyst gradually empties it-

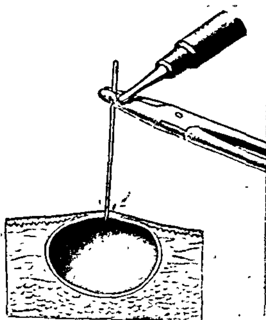


Fig 106 Insertion of the needle and application of the electrode as the current is turned on. (Danna, J. A.: Ann Surg. 123:953)

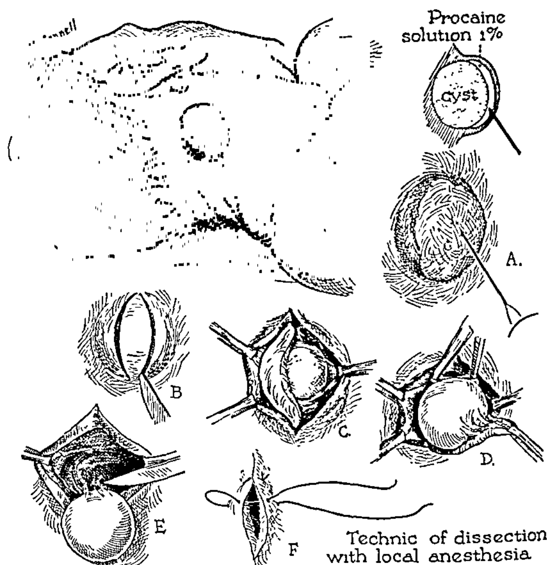


FIG. 105. Excision of a sebaceous cyst of the neck. Procaine hydrochloride solution, 1 per cent, is infiltrated over the cyst (A). It is frequently possible to insert the solution between the cyst capsule and the surrounding tissues so that the dissection may be partly performed by the local anesthetic injection. When the cyst is so large that the skin is stretched over it, an ellipse of skin may be excised with the cyst (B). If the lips of the wound are kept on tension by finger pressure or by grasping the edges of the wound with Allis forceps (C), the dissection may be partly accomplished without manipulation The tissues under the cyst are dissected bluntly with a curved hemostat (D, E). The wound is closed with vertical mattress sutures, the deep portion of which grasp the bed of the cyst (F).

is seen definitely as a black depression on the skin, and occasionally it is so dilated as to permit the sebaceous contents to be expressed from the cyst by pressure. On the scalp, the cysts may become large in size, sometimes as large as a small orange (Fig 104).

Symptoms. Sebaceous cysts cause few symptoms except disfigurement or the discomfort caused by their pres-

has taken place, a wide excision of the cyst should be performed. The grade of malignancy is usually low, metastasis is late, and, as a rule, if a sufficiently radical operation is performed, a cure is obtained.

IMPLANTATION OR EPIDERMOID CYSTS

Etiology. These cysts appear as a result of injury, usually by a blunt object, in which a bit of epiderm is driven beneath the skin surface.[2] When healing takes place, the displaced epiderm acts as a skin graft and grows to form a subcutaneous cyst, the cyst resulting from the distention of the implanted skin with desquamated epithelium and sebaceous material.

Diagnosis. Epidermoid cysts are almost always seen on the palmar surface of the hands and the fingers or on the feet, areas in which ordinary sebaceous cysts are not usually found. As a rule, a history of an injury is obtained, and a scar may be visible over the cyst swelling. Usually, the implantation cyst is attached to the undersurface of the skin at the site of the scar. Except for being disfiguring or inconvenient, these cysts cause no symptoms. Occasionally, due to trauma because of their exposed position, they become painful (Fig. 385).

Treatment. Treatment is by simple excision, usually they do not shell out with a well-defined capsule as do the sebaceous cysts. The operation can be performed under local anesthesia without difficulty.

DERMOID CYSTS

Etiology and Pathology. Dermoid cysts appear along the lines of embryonic fusion and develop from inclusion of displaced dermal cells along these lines. Histologically, their walls are thick and fibrous, lined with squamous epithelium which resembles skin; they usually contain hair follicles and sebaceous and sweat glands. The contents of the cysts are cheesy, sebaceouslike material, at times mixed with hair. Only very rarely are other structures, such as cartilage and bone, found in them. In many cases a sinus may be noticed, through which the contents of the cyst may be expressed.

Types and Treatment. By far the greater number of these congenital inclusion cysts appear in the region of the head and the neck. They occur in definite groups corresponding to various lines of embryonic fusion. Most commonly they appear about the outer canthus of the eye, about the eyebrow (Fig. 108) and in the orbit, originating along the naso-optic groove, which lies between the maxillary and the mandibular processes.[17] These cysts usually appear in early life. They are deeply attached to the periosteum along the orbital ridge and, therefore, can be easily distinguished from sebaceous cysts, which move over the underlying tissues but are attached to the skin. Occasionally, they produce a craterlike depression in the underlying bone.

Excision is the treatment of choice; it can usually be performed under local anesthesia. The surgeon must be prepared, however, to have adequate exposure and assistance, because there is sometimes difficulty in freeing the cyst from its attachment to the underlying periosteum.

It is more difficult to explain the formation of dermoid cysts of the nose. Suffice it to say that they occur along the bridge of the nose and in the upper lip at the base of the columella. Almost always they are present at birth or appear in early infancy,

self, the cavity gets smaller and smaller till the bottom of the cavity finally presents on the surface." This "soon levels off in a straight line with the surrounding skin. There is no drainage of any consequence during this time."

When the cyst is infected, simple incision and drainage are indicated. Occasionally, the cyst wall may lie free in a pocket of pus, in which case the cyst itself may be removed. No extensive dissection of the cyst wall should be performed in cases of infection, first, because there is the danger of spreading the infection and, second, because the dissection is difficult and one cannot be sure that the entire cyst wall has been removed. Furthermore, infection may result in a cure of the cyst after a simple incision. In some cases of infection, it may be well to cauterize the wound with phenol in an effort to destroy the epithelial lining of the cyst. Instead of phenol, Fishman[19] places a small piece of silver nitrate crystal in the cyst cavity after evacuating the pus and the sebaceous material through a small stab wound. The next day the cyst wall usually is loosened from the surrounding tissue so that it can be picked out of the wound with forceps.

When carcinomatous degeneration

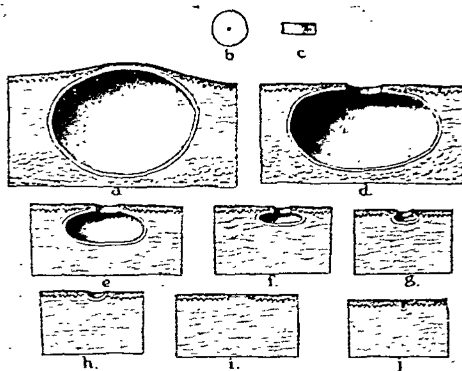


Fig. 107. (a) Section of intact cyst. (b) Superficial view of button of tissue that sloughs out. (c) Lateral view of b. (d) Cyst after slough has separated. (e, f, g, h) Various stages of diminution in size of cavity. (i) Final leveling off of cyst wall, the usual result in uncomplicated cases. (j) The result in 6 cases following previous excision or preoperative inflammation and infection. (Danna, J. A.: Ann. Surg. 123:953)

moved easily by surgical excision under local anesthesia.

Papillomas

Small papillary growths occur on the skin in many areas. They consist of a layer of skin covering a central stalk of fibrous tissue, which contains a nutrient artery and vein. These tumors appear often on the back (Fig. 110) and in the axilla and occasionally on the neck. They give no symptoms unless they are traumatized, at which time they become edematous and somewhat painful. Occasionally, trauma produces a thrombosis of the central vessel supplying the papilloma and a dry gangrene occurs.

Treatment may be by one of several methods. They may be easily removed by ligation at the base with a silk thread. This shuts off the blood supply, and the portion of the papilloma distal to the ligature becomes gangrenous and falls off. Another method is excision by electrodesiccation after injection of the base with a small amount of local anesthetic. When the papilloma is especially large, it is perhaps better to excise it under local anesthesia and suture the wound with one silk suture.

Warts or Verrucae

A wart, or verruca, is a benign epithelial new growth formed by hypertrophy of the papillae. It may occur at any location on the cutaneous or the mucous-membrane surface. These lesions are believed to be infectious and are thought to be caused by a filtrable virus. They are auto-inoculable and can be transferred from one person to another by inoculation. They have been given names according to the shape or the location of the wart. The four chief clinical varieties are verruca vulgaris, the common wart; verruca plana juvenilis, the flat juvenile wart; verruca plantaris, the plantar wart; and verruca acuminata, the venereal wart. Other minor types are the verruca digitata, a growth with numerous fingerlike processes, and the verruca filiformis, which has long threadlike pedunculated cutaneous tabs and is seen most often on the face, the neck and the eyelids. The so-called seborrheic and senile warts are not classified under the verrucae; they are really keratoses, have a different histopathology and are precancerous lesions.

Verruca Vulgaris. The ordinarily common warts are seen more often in children, but they are also encountered in adults. They occur most commonly on the hands and the fingers; however, they may appear at any place on the skin or the mucous membrane. They may be single or multiple. Histologic examination shows definite changes in the papillary layer of the corneum due to irritation and alteration of the blood supply. There is often marked displacement of the underlying layer of the skin but never a break in the continuity of the corneum. These warts cause few symptoms, except disfigurement. Occasionally, because of trauma, they will bleed or become infected. Those which are found underneath the nails (Fig. 450) or on the plantar surface of the foot may cause discomfort due to pressure.

In discussing the treatment of common warts, it should be pointed out that these lesions may disappear spontaneously or with relatively simple types of treatment; on the other hand, they may be so recalcitrant as to defy almost any method of therapy. There seems to be good evidence that they



FIG. 108 (*Left*). Dermoid cyst at the usual location along the outer portion of the eyebrow.

FIG. 109 (*Center*). Cutaneous horn on the dorsum of the hand. This lesion was excised under local anesthesia.

FIG. 110 (*Right*). Pedunculated papilloma of the back.

and they are marked by the presence of a small sinus opening over the cyst. They cause no symptoms, except disfigurement, but frequently they become infected

The treatment of dermoid cysts of the nose is excision. The sinus opening, when present, is excised by an elliptical incision with the cyst. It is not always easy to remove these cysts, especially those over the bridge of the nose, because usually they are firmly attached to the periosteum and they may have a tract of dermoid tissue which extends down between the nasal bones into the septum. In such cases removal of the tract is difficult. They may, perhaps, be better treated by destroying the epithelium either by diathermy, as recommended by New and Erich,[36] or by the application of Carnoy's solution (p. 17).

The third group of inclusion cysts arises from epidermoid tissue which is sequestrated during the union of the first and the second branchial arches to produce cysts in the floor of the mouth and the neck. These are discussed in detail in Chapter 16. They may reach a considerable size, the treatment is excision.

CUTANEOUS TUMORS

CUTANEOUS HORNS

Cutaneous horns are hard, hornlike projections extending above the level of the skin; they develop due to a marked type of keratosis of the horny layer of the skin, which fails to be discarded. The skin surrounding the base of the horn is usually normal in appearance. As time goes on, these lesions may grow to considerable size (Fig. 109). They may occur anywhere on the body, but most often they appear on the head, the back and the extremities. They are frequently found in older people and should really be regarded as a type of senile keratosis. Their danger lies in the fact that approximately 12 per cent of them become malignant. They may be re-

moved easily by surgical excision under local anesthesia.

PAPILLOMAS

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disappear spontaneously by psychotherapy or suggestion treatment. It is impressed upon the patient that the warts are sure to disappear, and some simple method of psychotherapy, such as painting the lesions with a colored solution or some placebo treatment, may be given in addition.

Hutton[22] has described a treatment by the injection of sclerosing solutions into the base of the wart. This is made without anesthesia, a tuberculin syringe and a fine-gauge needle being used. Any of the solutions used for the injection of varicose veins, such as quinine and urethane or sodium morrhuate solution, may be used. The heavier solutions appear to have a distinct advantage in that they remain localized at the point of injection Only a few drops are injected. After a few days, the wart becomes dry and hard, and, after 10 to 14 days or longer, depending upon the size of the wart and the thickness of the surrounding skin, the wart comes off or can be trimmed off, leaving a practically normal skin underneath. The author has used this method of treating warts with complete success in many cases.

The pedunculated type of wart may be removed easily simply by clipping it off with scissors after the injection of local anesthesia at the base The remaining tiny wound is treated by a simple pressure dressing or by superficial electrodesiccation

Surgical excision of these common warts is an excellent method of treatment, depending upon the site of the lesion. If it is located where it can be excised and the remaining wound sutured without difficulty, this is probably the most rapid and the surest method of treatment. When the wart is located over an articulation, however, or when the skin is tense, excision is not indicated.

Most dermatologists[40] depend upon electrodesiccation or irradiation for removing warts. With electrodesiccation, the needle is inserted into the wart several times, a very mild current being used. The dehydrated wart is then removed either with scissors or a sharp curet, care being taken that the "core" is removed. The base is then very mildly and superficially desiccated, leaving a dry scab, which may be conveniently dressed by touching the area with 1 per cent gentian violet and permitting it to dry. No further dressing is necessary. Sutherland-Campbell[47] has used desiccation by another method: with a very fine spark, the verruca surfaces are seared lightly. This procedure is repeated at weekly intervals, and involution and desquamation of the lesion occur within 6 weeks. He recommends this method for verrucae which do not respond to the usual methods of treatment, and has been successful in removing warts which were resistant to roentgen and radium therapy.

Roentgen and radium irradiation of warts is a well-recognized method of therapy, but it should be applied only by a dermatologist or a radiologist who is familiar with the technic of these media. This therapy is of particular value for warts occurring at the side of and underneath the nails because it is so difficult to treat warts at these sites by other methods. It is also excellent for treating multiple warts in a localized area. Fisher and Chamberlain[18] warn against the use of roentgenotherapy because of ulcerations that may appear as a result of too vigorous treatment. They have found that many warts will disappear with a daily dose of vitamin A,

Fig. 111. Keloid of shoulder following minor injury. (Eliason, Eldridge L., Ferguson, L. Kraeer, and Sholtis, Lillian A.: Surgical Nursing, ed. 10, Philadelphia, Lippincott)



100,000 international units for from 1 to 6 weeks.

Various local applications also have been useful in the treatment of verrucae. Fuming nitric acid has been used for many years, the application being made with a wood swab stick after the area surrounding the wart is protected with petrolatum. Several applications, at intervals of from 5 to 7 days, may be necessary. More recently, bichloracetic acid has been used in the same way. By these applications, the warty growth becomes hard and black. This dead tissue must be removed with a scalpel or a curet before the subsequent application of the cauterizing solution. Usually, not more than two or three applications are necessary.

Lurie[28] has reported excellent results in the treatment of verrucae by the intramuscular injection of bismuth subsalicylate in a 10 per cent suspension in vegetable oil. From 1 to 2 cc. is given once a week to adults. If the bismuth compound is used, the urine should be examined before beginning, and frequently during, the treatment. On the appearance of albumin or casts, the treatment should be suspended. Usually, a series of 8 weekly injections is considered to be a full course. Treatment should be stopped on any evidence of saturation with the drug, as, for instance, itching skin eruption, blue line on the gums and so forth. This therapy may prove to be valuable in the treatment of multiple warts.

Verruca Plana Juvenilis. This is the term for the small flat skin-colored or light-yellow lesions; they occur chiefly on face, neck and hands. They are smooth, only slightly raised, and not warty to the touch; they are seen most often in children, but they do also occur in adults, and are multiple in number. Probably the most effective method of removing such lesions is either by excision under local anesthesia or by electrodesiccation.

Verruca Plantaris and Verruca Acuminata. These lesions will be discussed in detail in the regional surgery of the feet and the anal regions.

FIBROUS TUMORS

Keloids

Etiology. Keloids are irregular overgrowths of fibrous tissue occurring in scars. They are raised above the surrounding skin and frequently become almost pedunculated (Fig 111) They always result from some injury to the skin or the deeper tissues, although

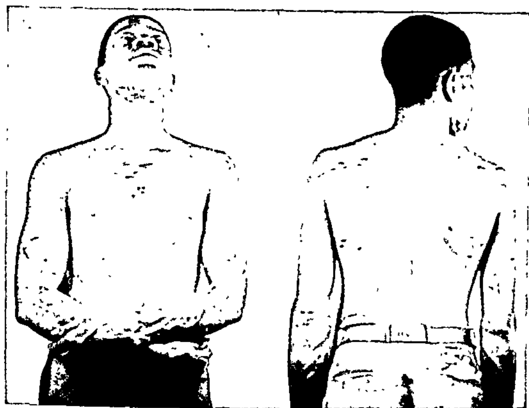


Fig. 112. Multiple keloids in a Negro. Every slight injury to the skin in this patient had resulted in a keloid growth.

the injury itself may be minor in nature, such as a mosquito bite or an acne furuncle. In the Negro race there is a definite predisposition to the formation of keloids (Fig. 112); in the white race it is sporadic. In the Negro race this predilection appears to be present in adult life, whereas in the white race it is more likely to be present in childhood.

Pathologically, the keloid overgrowth is composed of dense bundles of fibrous and hyaline connective tissue covered by a thin layer of epithelium. There are no glands or hair follicles, but numerous small blood vessels and lymphatics are found. Usually, no symptoms are produced by the keloid, except disfigurement, but occasionally there is itching; also rarely, there are pain and tenderness. These keloids are found most commonly on the exposed portion of the body, the hands, the arms, the face and the neck, and over the chest. Growth is usually slow; the original injury apparently heals normally, then there is a slow but progressive enlargement of the scar until eventually it assumes the proportions of a true keloid. In rare instances, ulceration or infection follows trauma to keloids; there is practically no tendency toward malignancy.

Treatment. The treatment of keloids varies somewhat according to the stage at which the lesion is seen. While they are forming, irradiation with radium or roentgen rays appears to give excellent results. These treat-



Fig. 113 (*Left*). Large lipoma of the upper arm

Fig. 114 (*Right*). A typical lipoma of the lower neck. These tumors are so soft that they frequently appear to be fluctuant

ments are given at intervals of from 1 to 6 weeks over a period of several months. In old, well-formed keloids, there is a difference of opinion as to whether irradiation or surgery plus irradiation is preferable. Garb and Stone[20] warn against the topical application of various agents, and various forms of injections (fibrolysin) have been unsuccesful. They agree with Costello[13] that roentgen rays and radium are the only effective treatment for keloids. In large old keloids, which are often radioresistant, surgical excision is recommended, with irradiation at the first sign of recurrence.

Efforts to use ACTH in reducing fibroplasia have been unsuccessful in the treatment of keloids,[45] although Conway and Stark[12] claim that when ACTH was mixed with hyaluronidase and injected into the keloid, pain and ... g disappeared and the keloid appeared to become softer after a series of 5 weekly injections.

Lipomas

Lipomas are tumors composed of adipose tissue. They may appear in almost any location in the body, but are most commonly seen in the subcutaneous tissues over the neck, the back and the buttocks and in the proximal portions of the extremities. They may appear at any age, but are rare in children as compared with the incidence in adult and late life. They vary greatly in size—from that of a hazel nut to the size of a baseball, or even larger (Fig. 113) They also vary greatly in consistency, depending upon the amount of fibrous tissue in them and upon the tissue in which they are found. The lipomas of the side of the neck are soft, almost fluctuant (Fig. 114); they are easily movable in the





FIG. 115 (*Left*). A typical lipoma of the back of the neck. These tumors are relatively hard, firm, fixed masses due to fibrous tissue bands which extend from the underlying fascia to the undersurface of the skin.

FIG. 116 (*Right*). Demonstration of the orange peel appearance in a lipoma by pressure with the fingers

tissues and have no very definite encapsulation. On the other hand, tumors of the back of the neck and the forehead and the multiple tumors of the arms usually contain a large amount of fibrous tissue, are hard masses which lie in a fairly well-formed capsule, and are fixed to the tissues by fibrous septa which traverse them (Fig. 115). Frequently the soft, fluctuantlike tumors must be differentiated from cysts, whereas the harder, firmer tumors must be distinguished from fibromas, sebaceous cysts and sarcomas.

Pathology. Pathologically, lipomas are composed of fatty tissue containing a variable amount of fibrous tissue. In the soft type, the fat lobules are large in comparison with the normal fat in the surrounding tissues, this is a distinct aid in the excision of lipomas, as it makes it easier to identify the fatty tissue of the tumor.

Symptoms. The symptoms caused by lipomas are few: the masses produce disfigurement, and, rarely, following trauma, they become painful or tender.

Diagnosis. There are several points which are helpful in distinguishing lipomas from other superficial tumors In the soft type, there is a definite attachment of the skin by fibrous-tissue bands to the lipoma so that pressure upon the tumor produces an orange-peel-like surface (Fig. 116). In large lipomas, the skin surface appears to be cooler than the surrounding skin The absence of the symptoms of acute inflammation and the long duration of the swelling make the diagnosis between lipoma and abscess a relatively simple one Lipomas rarely develop malignant change, but their removal is indicated because of the disfigurement or the discomfort produced by them

Treatment. Almost all lipomas may be removed under local anesthesia in

ambulatory patients. The operation is performed by field block or local infiltration, and in most cases the line of cleavage between the tumor and the surrounding fatty tissues is easily demonstrated. Tissue tension produced by firm retraction is of value in reducing the amount of bleeding and in permitting more rapid dissection. Often, lobules of the tumor lie in pockets formed by fibrous tissue septa, and retraction will permit these lobules to be withdrawn with the tumor. The blood supply of the tumor usually enters it from below, and this is the only area which needs clamping and ligation. After removal of the tumor, it is important that the dead space remaining be obliterated, if possible, with interrupted buried sutures; mattress sutures should be used in the skin. A pressure dressing is applied to prevent the accumulation of blood or serum in the wound

Multiple fibrolipomas occur frequently on symmetrical portions of the arms and the body. These appear as hard, smooth masses in the subcutaneous tissues and are frequently somewhat tender and painful (Fig. 335). The tender tumors may be removed as desired by the patient.

Fibromas

Fibromas (Fig 117) are hard, rounded, movable, slow-growing noninflammatory tumors. They are found usually in adults, in the skin or the subcutaneous tissues almost anywhere on the body. On section, they are composed of bundles of connective tissue which are almost cartilaginous in their hardness.

Fibromas usually cause no symptoms, except disfigurement, or, occasionally, slight pain due to trauma. On palpation they are sometimes very similar to sebaceous cysts and must be distinguished from them. Sebaceous cysts are always attached to the skin at the exit of the duct, whereas the skin moves over fibromas, which in turn are usually movable over the underlying tissues



Fig. 117 Fibroma, dorsum of hand.

Fibromas almost never undergo malignant degeneration.

Treatment. When, for any reason, it seems to be desirable to remove a fibroma, excision may be performed under local anesthesia without much difficulty.

VASCULAR TUMORS

Hemangiomas

It is generally believed that hemangiomas are true neoplasms rather than simple dilations of normal vessels, as are varicose veins. They are the most common tumor of childhood, and, according to Young,[50] are present at birth in 83 per cent of the cases. The remaining 17 per cent almost invariably appear before the patient is 3 years old. They may appear in any location on the body and in any tissue, but they occur most often in the skin and the subcutaneous tissues, although hemangiomas of the mucous membranes and the muscles are not un-



Fig. 118 Plexiform hemangioma (strawberry mark) on the scalp. This lesion is best treated by surgical excision.

common. The fact that they appear frequently on the skin of the face makes them disfiguring blemishes, which is one reason for their early treatment. As a rule, hemangiomas are benign in nature. They are not definitely encapsulated, but are usually well demarcated from surrounding tissues. Occasionally the growths spread rapidly and take on malignant characteristics, and, very rarely, they even produce metastasis. The type most likely to spread is the hypertrophic plexiform hemangioma or strawberry mark. This may start as a relatively small growth in early life and spread rapidly, producing wide destruction of tissue. Because of this malignant type of change in some of these lesions, early treatment is advisable.

Hemangiomatous tumors may be divided into two main groups—the capillary and the cavernous. Of the capillary hemangiomas, there are two chief types, the hemangioma simplex or port-wine stain and the plexiform or hypertrophic endothelial hemangioma, often referred to as the strawberry mark.

Capillary Hemangiomas

Hemangioma Simplex (Port-Wine Stain). The capillary hemangioma or port-wine stain is the simplest of these vascular lesions. It consists of an increased number of dilated capillaries and venules in the deeper layers of the skin, over which the epidermis may be very thin, frequently with a velvety surface. It appears as a poorly defined, irregular reddish or purplish area not raised above the skin; it occurs most commonly on the face or about the neck, but it may appear anywhere on the skin surface. The simple hemangioma does not tend to spread or become malignant. In rare instances, the tumor disappears spontaneously. This is most likely to take place in the bright-red telangiectatic dilatations that appear on the back of the neck and over the forehead.

The treatment of hemangioma simplex is somewhat difficult. The object of the treatment is to remove the disfiguring blotch either by excision or by closure of the dilated vessels which produce it. In small tumors, excision, with or without skin graft, may be the preferable method of therapy. However, other methods of treatment are available. Irradiation, either with roentgen rays or radium, is particularly effective in the first year of life. As the child gets older these tumors become more radioresistant; nevertheless, irradiation therapy is an excellent method of eradicating the port-wine stain. The application of carbon dioxide snow with firm pressure for 10 to 20 seconds may result in a thrombosis of the superficial capillaries and the disappearance of the purplish color. Both irradiation therapy and

carbon dioxide snow may produce a blanching of the area, which often becomes pearly white and smooth due to atrophy of the underlying tissues, so that successful treatment may substitute a white scar for the discolored area. MacCollum,[29] at the Children's Hospital in Boston, has had good results by using blistering doses of ultraviolet irradiation from an air-cooled lamp. These are given once a week for a period varying from 1 to 9 months, and, in his experience, the result is definite improvement or cure in 80 per cent of the cases

Plexiform Hemangioma (Strawberry Mark). The plexiform hemangioma or strawberry mark (Fig. 118) probably comprises the largest group of these tumors. It is slightly raised above the skin and is lobulated. It is either a reddish or a bluish color, depending on the amount of arterial or venous blood in it. There is great variation in size, but the majority are relatively small in diameter They occur anywhere on the skin but are found most commonly on the face and the head. They are composed of widely dilated capillaries and venules with very little perivascular connective tissue. The true skin and subcutaneous tissues are displaced by masses of endothelial cells Not uncommonly, there may be palpated in the subcutaneous tissues a mass which extends out beneath the surrounding normal skin. This is the type of hemangioma which sometimes progresses rapidly and which demands treatment in early infancy.

Treatment of Strawberry Mark. There are several methods of treatment. Probably the most effective and the one to be recommended, when possible, is excision This gives the most rapid and the surest results, and, in cases of small hemangiomas, it can be performed easily. There may be times, however, when, because of the age of the patient, there is parental objection to surgery, or, because of the location of the tumor, as, for instance, on the nose, surgery may not be advisable. In MacCollum's[29] experience of 418 cases, only one half were of the proper size or in a position in which excision was deemed to be advisable

When surgery cannot be performed, various other alternative treatments are available. MacCollum uses carbon dioxide snow, applying it with pressure for 10 to 20 seconds at 6-week intervals. Irradiation by radium and roentgen rays has been used by numerous authors.[43]

Brown and Byars[6,8] have obtained excellent results from interstitial irradiation. They implant gold radon seeds of 0 25 to 0.5 millicuries into the hemangioma, calculating the total dosage as 1 radon seed per cc. of tissue to be irradiated Within a week's time there is definite decrease of the hemangioma, and the reaction reaches its peak in from 2 to 3 weeks with a speedy recession of the tumor mass. Continued improvement may occur for 6 months from a single treatment; subsequent implantation may be made if necessary.

Kaessler[21] has reported excellent results from the injection of 20 per cent quinine dihydrochloride and urethane diluted with an equal part of 2 per cent procaine hydrochloride with epinephrine. A short 26-gauge short-bevel needle is directed along radial paths from a single injection site The solution is deposited superficially throughout the mass, from 0.1 to 0.2 cc being injected at one time. Immediate blanching of the area occurs

about the needle point, the needle is then advanced and the next injection is placed so that the second area of blanching is contiguous with the first. The process is continued until the entire lesion has been mottled with areas of blanching. Pressure is applied over the entire injected area by a small gauze pad held in place with adhesive. This is removed after 48 to 72 hours. Repeated injections may be necessary at monthly intervals. Sloughing occurs only rarely and heals without disfiguring scarring. In 41 hemangiomas, Kaessler obtained excellent ultimate results; there were no recurrences.

Macomber and Wang[33] use 5 per cent sodium morrhuate as a sclerosing agent. They inject 0.2 cc. of the solution as a test dose, and, if no sensi-

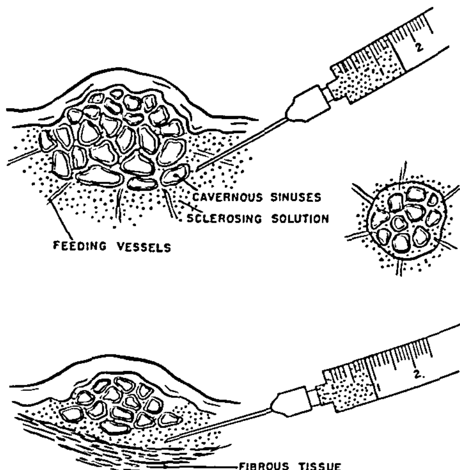


FIG. 119 Diagrammatic illustration of the injection treatment of hemangioma (*Top*) Early treatment: Note the sclerosing solution infiltrates round the vessels and the cavernous sinuses at the base and the periphery of the lesion. (*Bottom*) Late treatment: Note the fibrosis at the base of the lesion produced by previous injections The sclerosing solution is now infiltrating the tissue above the fibrous layer and below the remainder of the lesion. (Macomber, Brandon W., and Wang, Mark K. H.: The Hemangioma, GP, Vol 8, No. 5, p. 48)

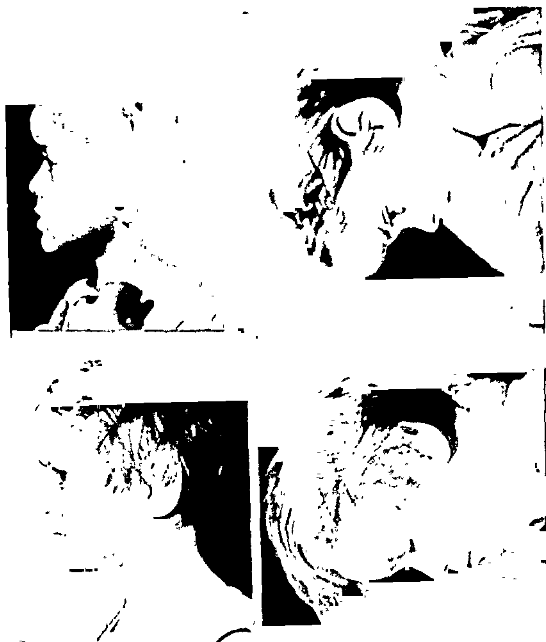


Fig. 120. Sinus pericranii (*top, left*) partially emptied in the upright position, (*top, right*) filled in the dependent position and (*bottom*) obliterated by injections of sodium morrhuate. (Peyton, William T., and Leven, N. L., Surgery 3:702-718)

tivity is shown, a therapeutic dose of 0.5 to 5 cc. is given, depending on the size of the lesion. Repeat injections may be given in 6 weeks. The injection is followed by localized redness, swelling, tenderness and, occasionally, blister formation. This gradually subsides in 1 to 2 weeks, leaving a blanched indurated area which gradually becomes soft and smooth.

Cavernous Hemangiomas

The cavernous hemangioma consists of large blood spaces or sinuses lined

with endothelium. These vary greatly in size, and there is considerable variability in the amount of connective tissue which lies between the sinuses. This lesion may be found not only in the subcutaneous tissues but also in the mucous membranes and, less frequently, in the muscles and the deeper organs. On the skin, the cavernous hemangioma appears as a definite swelling with a bluish or a reddish-blue tinge transmitted through, rather than in, the skin; the swelling is compressible and may be emptied by pressure or elevation, depending upon its location. Conversely, straining or crying may make the tumor become tense and larger. This characteristic often makes the lesion a terrifying one for the mother, who notices the definite enlargement when the child cries. The lesion usually is present at birth and gradually increases until puberty. Very frequently it is combined with a lymphangioma.

One specific type of cavernous hemangioma is given the name of sinus pericranii. This is applied to the hemangioma of the pericranium which communicates by abnormal foramina through the skull with the dural sinuses (Fig. 120). As a rule, it is congenital in origin and appears as a soft, compressible, fluctuant swelling which increases in size with increases in venous pressure. It is seen most frequently over the forehead, less often along the sagittal sinus and over the occiput. Roentgenologic examination frequently demonstrates abnormal openings in the skull, and often phleboliths may be palpated in the mass when the blood has been drained or expressed by pressure.

Treatment. The treatment of cavernous hemangioma varies in different hands. Here again surgery is recommended when the lesion is in such a situation that it can be excised safely. MacCollum[30] has used carbon dioxide snow in a few cases, but, in most instances in which surgical excision cannot be performed, he treats the lesion by endothermic coagulation. This operation is performed under general anesthesia and should probably be done in the hospital. The principle of the treatment is to pass a coagulating current of low intensity through a needle which is inserted in the hemangioma until the tumor tissue immediately adjacent to it becomes blanched. The needle is then reinserted at intervals of about 1 cm. and the procedure is repeated. Care must be taken that too vigorous coagulation does not result in a slough. Peyton and Leven[42] have used sclerosing solutions with more satisfaction in these lesions. These authors inject a solution of 7 per cent sodium morrhuate, introducing the needle into the vascular spaces and withdrawing it until blood is obtained by suction. The amount injected varies from a few drops to about 2.5 cc. Manual compression is maintained until a rubber-sponge pressure bandage has been applied over the area. At the injection, a stinging or burning sensation is experienced. This lasts only a short time and is followed by a definite painful sensation for an hour or more. Moderate compression reduces the amount of discomfort experienced. There follows in the next day or two a definite swelling with discoloration and edema, which eventually subsides as the vessels in the hemangioma become thrombosed. Peyton and Leven have used this method of therapy in sinus





Fig. 121. Granuloma pyogenicum (infectious granuloma). Both of these lesions appeared in the hand following subcutaneous infections. Both responded to cauterization with silver nitrate stick.

pericranii with very excellent results. they have never seen a thrombosis extend beyond the lesion itself.

Irradiation as a method of treatment of these hemangiomas also has its advocates. Brown and Byars[6] use interstitial irradiation.

After the cure of the hemangioma by any of these methods, a plastic operation may be necessary to improve the cosmetic result.

Hemangiomas and Lipomas

Another type of hemangioma, which not infrequently is seen, is that combined with lipomas. These appear in childhood and produce marked swelling and deformities with discoloration The mass is a firm one, fixed in the subcutaneous tissues. No effort should be made to inject such lesions, and the treatment by irradiation or carbon dioxide snow is not satisfactory. Excision of the mass, which can be performed under local anesthesia, is curative.

Granuloma Pyogenicum

Diagnosis and Symptoms. Granuloma pyogenicum should really be classified as an infection of the skin, but, because of its tumorlike form and because it must be differentiated from tumors, it will be discussed here. This lesion is a reddish wartlike, often pedunculated, tumor of the skin. It is usually characterized by a surrounding collar of thickened bluish-white macerated epithelium. In the author's experience, it practically always follows some local injury which becomes the site of a low-grade staphylococcal infection. The infection remains local-

ized, but the process continues with the piling up of granulation tissue at the local area of injury. The maximum growth of these tumors is about the size of a pea, and the chief symptom is bleeding, which occurs on the slightest trauma. Most often, the granulomas are found in the areas in which injury is frequent, as, for instance, in the hands and the fingers (Fig. 121), less often they are found on the lips and the face. Patients usually seek treatment because of the marked bleeding, and a diagnosis has been made of a malignant tumor because of this symptom. Furthermore, there is sometimes a tendency to recurrence if the entire granulating area is not removed The differentiation from carcinoma is easily made, however, because of the lack of invasion of the surrounding tissues and because of the history of local injury.

Pathology. On histologic section the tumor is found to be made up of a mass of newly formed blood vessels surrounded by young connective-tissue cells In addition, there is a moderate leukocytic infiltration.

Treatment. The treatment of granuloma pyogenicum is relatively simple, the chief indication being to destroy completely the hypertrophic granulation. This may be done most simply by excising the tumor with scissors. Considerable bleeding may follow this procedure, but this can be controlled by pressure, or, if the tumor mass is in a position in which a tourniquet can be applied, this should be done before excision After the granuloma has been removed, the base should be cauterized with pure phenol or with silver nitrate stick. A simple pressure dressing may then be applied. This method offers the simplest and the most rapid method of treatment in these cases. The tumor may be destroyed by electrodesiccation in the same manner and with the same results. Because the lesion usually follows a staphylococcal infection, antibiotics to which the organism is sensitive are often used also. Penicillin is the antibiotic of choice.

The use of irradiation by roentgen rays or radium has been advocated in the treatment of granuloma pyogenicum. This undoubtedly gives good results, but it takes a period of from 4 to 5 weeks for the tumor mass to disappear.

Glomus Tumors

Pathology and Etiology. The neuromyo-arterial glomus is a normal structure found in the fingers, the nail beds, the toes, the feet and perhaps elsewhere in the skin. It is probably a peculiar type of arteriovenous anastomosis; the blood vessel is usually twisting or S shaped and is thin walled, surrounded by a rich network of sympathetic-nerve fibers and nontypical muscle fibers. It is believed that the normal physiologic function of these organs is the maintenance of a constant capillary pressure and control of peripheral temperatures. This normal structure may become a tumorlike mass and give very definite symptoms The cause of the enlargement or the development of the tumor appears to be trauma in about one half of the cases; or, at least, there is a history of injury in this proportion.

Symptoms and Diagnosis. Local hyperplasia of the glomus is characterized by the appearance of a small exquisitely tender bluish or reddish-blue nodule. Clinically, the tumor is associated with paroxysms of extremely severe pain localized in the region of the glomus or at times radiating from

it. The pain may be induced by pressure or other slight traumas and, at time, by changes in temperature. Frequently there is localized sweating associated with the paroxysms.[27]

On examination, the tumors vary in size and appearance according to their location. One common type is found under the nails of the fingers and the toes Here the lesion appears as a small purplish area, and it is excruciatingly painful when even the slightest pressure is applied to the nail. There may be some slight deformity of the nail distal to the tumor and some pressure atrophy of the distal phalanx. Shaving the nail so that it is extremely thin over the tumor may relieve the painful symptoms somewhat. Elsewhere in the skin the tumor varies according to its deep or superficial location Arising as it does from the glomus situated in the reticular area of the skin, the growth may expand superficially to lie immediately under the superficial layers of skin, and, in such cases, it appears as a purplish or a reddish dot which, when touched, gives extreme pain. The hyperplasia may also extend downward and project into the subcutaneous tissues, in which case there may be no discoloration of the skin and no visible or palpable evidence of its location. When the tumors are located in the soft tissues, they are slightly larger than the subungual lesions and usually are slightly raised elastic movable nodules in the subcutaneous tissues.

Treatment. The treatment of glomus tumor is excision; by its removal the painful symptoms are relieved immediately. At operation, at which there may be more difficulty than usual in obtaining good local anesthesia, a bluish-red, usually encapsulated, tumor is found attached to the skin in the soft tissues. This can be shelled out without difficulty. In subungual lesions it is recommended that the entire nail be removed and the tumor excised rather than that an attempt be made to excise it through a small opening in the nail. There is usually no tendency to recurrence after excision.

PIGMENTED NEVI AND MELANOMAS

Terminology. The confusion in nomenclature of the pigmented lesions of the skin is matched only by the controversy with regard to their origin and the best methods of treatment. The general trend is to include under the term *benign pigmented nevus or mole* the host of common and widespread benign pigmented lesions which few, if any, individuals are without. The terms *melanoma, malignant melanoma, melanosarcoma* and *melanocarcinoma* are reserved for those rare but highly malignant pigmented lesions which usually develop from a preexisting benign nevus

Pathology. The consensus is that these tumors arise as the result of a proliferation of the sensory end organ apparatus of the skin and are, therefore, neuro-ectodermal in origin.[5] Whether or not there is a mesoblastic component is not yet settled. The microscopic sections of melanoma may resemble carcinoma, sarcoma or endothelioma.

Benign Pigmented Nevi

The variety of lesions included under the term *nevus* is great. The simplest is the pigmented macula, nevus spilus. This is the common and widespread brownish mole. Some of them cover large areas of the body. Frequently the mole contains hair;

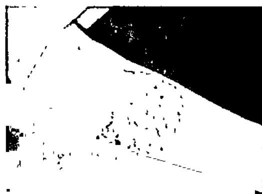


FIG. 122 Pigmented nevus of the pilose type This nevus was removed by multiple operations. Part was removed at one time and the wound was sutured, then more was excised at a later date. It is perhaps better to excise the entire nevus and apply skin grafts.

this type is known as pilose nevus (Fig. 122). Some forms are raised and flat, others are papillomatous or wart-like in character. It must be realized, however, that a nevus may be superimposed on other lesions, such as the wart or the papilloma.

The amount of pigmentation varies greatly Some are poorly pigmented and inconspicuous. At the other end of the scale is the highly pigmented blue-black or slaty smooth rounded shiny mole.

The nevus is the most frequent growth in man. Few individuals, if any, are entirely free from such lesions. Adair[1] found that the average person had at least 20 pigmented moles. They are found most frequently on exposed areas—scalp, face, chest, back and extremities. They are congenital in origin but may not be apparent at birth. The sexes are involved equally.

The nevus which is considered to be premalignant is the junction nevus.[23] This receives its name from the fact that the nevus cells grow actively at the dermo epidermal junction. It is flat and smooth, usually hairless, and from light- to dark-brown in color.[16] The common mole is the intradermal nevus. It is flat or raised and may contain hairs. Usually it does not have malignant potentialities, but the junction nevus may appear in combination with the intradermal nevus and form the compound nevus, which may be premalignant.

Since malignant melanomas are so rapidly fatal, and since it is so difficult, if not impossible, to determine clinically the presence of malignant change, it is only logical to consider the excision of moles as a prophylactic measure. The moles which should be looked upon with suspicion and which demand prompt action are those which show (1) increase in size or color (increase in pigmentation); (2) itching or pain; (3) irritation and discomfort; (4) infection; (5) bleeding, ulceration, weeping or crusting; (6) elevation and enlargement of a flat lesion.[31,48] Moles which are especially prone to become malignant are those appearing in blond individuals with pale soft skin. Moles located in the feet, genitals and under the nails are considered to be extremely dangerous.[40]

There appears to be good evidence that at least 50 per cent of malignant melanomas arise from pre-existing nevi. It is also recognized that "chronic irritation, infection and trauma seem to play a definite role in the production of malignant melanomas from pre-existing moles. Chronic irritation and trauma may consist of any of the following: irritation from shoes, collars, corsets, suspenders, brassieres, corn plasters, trauma from fingering

because of habit, combing of hair, repeated pulling of hairs, scratches, lacerations (shaving)." Moles subjected to these forms of chronic irritation or trauma should be removed as a prophylactic measure.[39,48]

Most authors agree that wide excision of the mole is the only adequate treatment. The excision should include a good margin of surrounding normal skin and the underlying fat.

Since nevi are radioresistant, they should never be treated by x ray or radium irradiation. There is also a definite danger in treating moles by electrocautery or electrodesiccation, since neval cells may not be completely destroyed and the irritation of the electrocautery may induce the remaining part of the tumor to grow more rapidly and even to become malignant.[39]

Melanomas

Melanoma is the most malignant of all skin tumors and one of the most malignant of all tumors. It constitutes about 1 per cent of all malignant tumors and causes from 0.5 to 1 per cent of all malignant deaths. Though this tumor may be found in a wide range of ages, it is most common in middle-aged individuals. There is no significant difference in incidence between the sexes. The areas of predilection are the head and the lower extremities, especially the feet.

Etiology. The varied microscopic picture which may be presented has been mentioned. The origin of most of these tumors is a pre-existing pigmented nevus, and, in many of the remaining cases, the patient may simply not have been aware of the existence of the original mole. Because melanoma usually develops from a pre-existing nevus which may have been present for years without giving trouble, the patient frequently delays seeking medical advice until the lesion is far advanced (Fig. 123). Melanoma may be quiescent for years, and moles, apparently benign, which are removed by chance, may show localized malignant changes.[1] However, once the melanoma begins to extend, the prognosis is poor and most patients die within 3 years. Rarely, a type of melanoma is seen which has very little pigment; this is called achromic melanoma.



Fig. 123. Malignant melanoma resulting from a pre-existing benign nevus.

Once melanoma has developed, the prognosis is poor, especially if the regional nodes are involved. Therefore, one should not temporize with doubtful nevi or those subject to trauma. The gross changes listed previously as evidences of malignancy mean that the melanoma is already well on its way toward extension, and hope for cure is slight. Indeed, extension may occur without local evidences of malignant change.

The treatment of a melanoma should not be attempted on an ambulatory patient.

MALIGNANT TUMORS

FIBROSARCOMAS

Sarcomatoid Fibromas of the Skin

Sarcomas of the skin are relatively infrequent. This type, which is seen occasionally, has been described and named by McMaster.[22] Its distinguishing characteristics are a single lesion, usually located on the trunk, most often on the abdomen, and the firm, painless, nodular character of the growth in the early stage, which later becomes a protruding, pedunculated mass growing away from the body. The mass is freely movable over the fascial layers and is often ulcerated on its surface. This tumor appears to invade the subcutaneous adipose tissues but not the fascia underlying them; it never metastasizes, and recurs only if inadequately excised. It usually appears in adult life.

On gross examination in their early stages, the tumors are seen to be located in the corium, on cut section, they are composed of firm grayish-white masses traversed by weblike interlacing strands. The larger lesions often ulcerate.

Treatment. These tumors are seen frequently in ambulatory patients, and they can be excised safely under local anesthesia if an area of skin and subcutaneous tissues sufficiently wide to prevent recurrence is taken with the tumor. Roentgen therapy following excision is recommended as a safety measure.

Fibrosarcomas of the Soft Tissues

These are mentioned in the consideration of the treatment of ambulatory patients because fibrosarcomas often appear on the extremities as hard, firm nodular masses and are frequently mistaken for simple fibromas. They arise from the fibrous tissue of intramuscular or fascial layers, from the adventitia of blood vessels and from nerve sheaths. They occur most often in persons past midlife.

Etiology. Trauma is probably not a factor in the etiology. Meyerding, Broders and Hargrave,[25] in a study of 152 cases, found no history of trauma in 102 patients. In the remaining 50, some type of injury preceded the appearance of the tumor, but in 31 of these it seemed that there was little more than an accidental association. In 17 of their cases, however, there seemed to be a definite etiologic relationship between trauma and the appearance of a sarcomatous tumor. Pack[41] has found no instance in which trauma was the sole etiologic agent in the formation of fibrosarcoma, but he believes that scar tissue due to burns, injuries or irradiation is often the site of fibrosarcoma.

Diagnosis. Very frequently the tumors arise in the subcutaneous tissues; usually there is no involvement of the overlying skin, but deep attachment is demonstrable. Most often they are smooth hard swellings, and the patients give a characteristic history of a comparatively rapid growth of the tumor mass (Fig. 124). A large proportion of these tumors seem to be encapsulated, and it is this feature which makes it so difficult to differentiate them from fibromas on superficial examination.

Pack[38] recommends an aspiration biopsy under local anesthesia. A small nick is made through the skin with a bistoury, and a 17-gauge needle is thrust into the tumor. A syringe is used to aspirate the tumor as the needle is advanced, but it is removed before the needle is removed. The specimen is smeared between slides, fixed

and stained, to be examined by an experienced cytologist.

The danger is that the tumor may be mistaken for a fibroma or a fibrolipoma and that an attempt may be made to perform a conservative operation (Fig. 125). At this time the true nature of the tumor usually is suspected because of the wide, deep attachment, often surrounding or including in its growth large arteries, veins and nerves.

Treatment. Conservative local removal is followed almost invariably by recurrence, and, even with more radical treatment, the prognosis is poor. Wide local excision, or perhaps even amputation, may be necessary. The reason these tumors are mentioned here is to point out the necessity for an accurate diagnosis and the advisability of hospitalizing patients with these lesions.



Fig. 124. Fibrosarcoma of the arm.

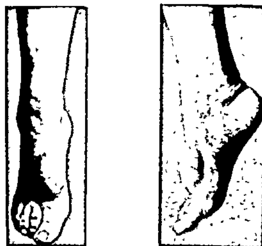


Fig. 125. Fibrosarcoma of the foot. This tumor was mistaken for a simple fibroma, and an attempt was made to excise it under local anesthesia The true nature of the tumor was diagnosed at the time of operation The patient refused amputation. The tumor recurred within 4 months with hemorrhage. The patient went to another hospital, where attempted local excision was followed by amputation and eventual death.

Cancer of the Skin

For practical purposes, cancer of the skin must be divided into two chief types—basal-cell cancer and the squamous-cell, or epidermoid, cancer.

Basal-cell Cancer

Basal-cell cancer, or rodent ulcer, is a malignant growth arising from the basal layer of the skin. It appears most commonly in individuals past midlife. It is relatively rare in the Negro race, but it is not uncommon in the white.

Etiology. This lesion practically always arises from some precancerous dermatosis, the most common of which is the seborrheic wart or senile keratosis frequently seen in elderly people These warts develop slowly and are slightly raised yellow-black areas covered over with a greasy-appearing

scale which is extremely adherent. They appear most often on the face, the neck, the back and the extremities, especially the hands and the arms. These lesions are believed by many to be caused by exposure to sunlight and wind; hence there is a predisposition in carpenters, sailors and farmers, who are much in the open, to the development of this type of carcinoma. It is found much more frequently in those who live in the country than in those dwell in the city.

Prophylaxis. In considering basal-cell carcinoma, attention should be directed to its prophylaxis by removal of these precancerous lesions at an early stage. Excision under local anesthesia with primary suture of the wound, especially in older people, may be regarded as wise prophylactic therapy.

Diagnosis. The basal-cell carcinoma occurs most often on the nose, the cheeks and the outer canthus of the eye, and over the temples. Occasionally, it occurs on the forehead, the ears and the trunk. The appearance of the growth may be flat, nodular, ulcerative or annular. Characteristic of all, however, is the hardness of the edges, which gives them a raised, heaped-up effect. The ulcers are covered with yellowish crusts or scabs, and there is an exudation of yellow, serous material; bleeding in small amounts is not at all uncommon, especially following slight trauma. Any shallow, bleeding ulceration which persists for several weeks on the face of one past midlife is, in all probability, a basal-cell carcinoma

Symptoms. Symptoms produced by basal-cell cancer are relatively trivial; occasionally, there is some itching or irritation, but most often patients seek treatment because of the ulceration which refuses to heal. The progress of the growth is usually slow, metastasis is rare, if it occurs at all, and for these reasons these tumors are a relatively benign and favorable type of carcinoma. However, should they invade bone or cartilage, the difficulty of cure increases tremendously, and they become invasive, destructive lesions which, even if cured, leave marked deformity.

Treatment. The average early basal-cell carcinoma can be cured if it is completely destroyed; it is important, however, that this complete destruction should occur at the time of the primary treatment. It makes little difference whether the treatment is by irradiation with roentgen ray or radium or by electrocoagulation or surgical excision so long as the lesion is completely destroyed or removed. The treatment for these lesions is best decided upon by consultation with the radiologist and the dermatologist. Many of them can be handled in ambulatory patients by relatively minor procedures such as excision, electrocoagulation or irradiation. Others demand more radical therapy. The best results are obtained by those who are trained in cancer treatment.

Squamous-cell Cancer (Epidermoid Cancer)

Etiology. Squamous-cell, prickle-cell or spinocellular carcinoma or epithelioma or epidermoid cancer is a new growth arising from the squamous-cell layer of the skin. It is believed to arise almost exclusively from chronic injury to previously normal or abnormal tissues It may result from injuries, various types of dermatoses, scars or ulcerations, and there now is definite information pointing to the possibility that various chem-

icals are etiologic factors in this type of cancer.

Diagnosis. Squamous-cell cancer occurs most frequently on the face, the ears, the scalp, the extremities and the genitals. Clinically, it appears in two forms: the ulcerative type, characterized by an indurated ulcer with raised edges and a necrotic base; and the cauliflower form, presenting a fungating, granulomatous or papillary appearance. The ulcerating type, although less malignant, has great destructive properties, it spreads along the periphery, the indurated edges breaking down to form a necrotic base. The edges are frequently undermined, and the tumor may spread from its undersurface as well as along its edges, thus invading deeper structures. The cauliflower type is less destructive, but it has greater malignant tendencies, and metastasis and recurrence are more frequent. This is especially true in cancer of the extremities. Metastasis is late in both the ulcerative and the cauliflower types.

Treatment. Treatment of squamous-cell carcinoma of the lip is discussed under Regional Surgery (p. 291). In the extremities, surgical removal or irradiation is the treatment of choice, depending upon the age and the physical status of the patient and upon the size and the type of the lesion. A combination of irradiation and surgery may also be advisable. It is wise for the surgeon to consult with the radiologist in deciding upon the method of treatment for the individual lesion.

GANGLIA

Pathology. A ganglion may be defined as a cystic swelling surrounded by a fibrous tissue wall and occurring in the region of the capsule of joints and tendon sheaths. The cause of the appearance of a ganglion has never been absolutely determined. For many years ganglia were thought to be herniations of tendon sheaths; more recently, following histologic studies, there is more universal acceptance of the theory that ganglia arise as a result of a degenerative process in the mesoblastic tissue surrounding joints and tendon sheaths and elsewhere in the body.

In a study of ganglia, Carp[11] demonstrated definite areas of degeneration scattered throughout the cyst wall. The collagen fibrils are broken up into fine threads. Spaced throughout at irregular intervals are rounded, spindle-shaped, or polygonal, cells, the cell bodies sometimes distended with vacuoles.

DeOrsay, Mecray and Ferguson[15] found that the gelatinous contents of the ganglion gave staining characteristics, which indicate that the material was myxoid and not mucinous. We view the process as a specific degeneration of collagen fibers. The elasticas are diminished in number, and the reticulum persists until complete cyst formation occurs; there is evidence of hyaline change round the areas undergoing myxoid degeneration. In the walls of the cyst, very definite perivascular fibrosis is found, and a number of the walls contain portions of nerve tissue. In every case, the nerve showed definite degenerative change, and it is quite probable that this involvement of nerve tissue may account for many of the painful symptoms associated with these lesions.

Mention should be made of the theory of King[26] concerning the pathology of ganglia. He believes that a metaplasia occurs in the specialized connective tissue round joint and ten-

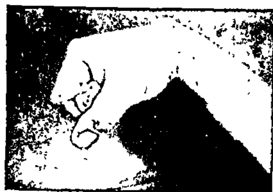




Fig. 126 (*Left*) Ganglion of the dorsal surface of the wrist. (DeOrsay, Ralph H., Mecray, Paul M., Jr., and Ferguson, L. Kraeer: Am. J. Surg. 36:313-319) (*Right*) Ganglion within a tendon on the dorsal surface of the wrist.





Fig. 127. (*Left*) Ganglion of the anterior surface of the wrist. (*Right*) Ganglion or mucoid cyst of the dorsal surface of the distal phalanx of the thumb. (DeOrsay, Ralph H., Mecray, Paul M., Jr., and Ferguson, L. Kraeer: Am. J. Surg. 36:313-319)



Fig. 128. Ganglion of the dorsal surface of the foot. This lesion developed after an injury in which a hand truck ran over the patient's foot. (DeOrsay, Ralph H., Mecray, Paul M., Jr., and Ferguson, L. Kraeer: Am. J. Surg. 36:313-319)

don sheaths: spheroidal cells develop in scattered, closely packed groups. These cells are seen to possess a vacuolated protoplasm and a central round nucleus. About the periphery of the group of spheroidal cells there is a gradual change into spindle cells. As the droplets accumulate in vacuolated spheroidal cells, this secretion is discharged into the intracellular spaces. The process continues until the extracellular collection separates the cells widely. Finally, there is the appearance of a small cavity. Several groups of spheroidal cells carry on this process, producing multiple cystic formations. These cysts gradually merge with each other due to the atrophy of the intercystic septa, giving rise to larger spaces. When the process ceases, the cells become less spheroidal in appearance and finally return to their original spindle shape, with the development of one single or numerous large cystic spaces and a few scattered nests of spheroidal cells in close proximity.

We have been able to demonstrate this method of formation of ganglia by histologic examination, but we are not prepared to accept the theory of mucinous secretion by spheroidal cells as the mode of formation. As a matter of fact, we believe that the process is one of myxomatous degeneration.

From a clinical point of view, these theories concerning the formation of ganglia are important because they have a bearing upon recurrence in the tissues. It is evident that whether the process initiating the formation of the ganglia is one of secretion produced by irritation or of degeneration produced by irritation, the same process may take place again if the irritation is repeated; therefore, the disappearance or the excision of one ganglion may not necessarily insure against the appearance of later ganglia if the same type of irritation is continued. Furthermore, in the excision of ganglia it is important to remove as much as possible of the involved tissue; to leave some behind may permit the redevelopment of ganglia at the same location.

Incidence. Ganglia appear about three times as often in females as in males. The majority of the cases appear in the second and the third decades of life and comparatively few in the later decades. The relation of trauma to the etiology of ganglia has not been definitely determined. Many believe that there is little evidence that trauma plays any part in the etiology of ganglia. King[26] is somewhat doubtful as to the relation of trauma to the formation of ganglia, but he believes that in some cases there is a definite relation. In 19 of 50 cases of ganglia studied personally there was a definite trauma associated with the appearance of the ganglion. It is apparent that trauma cannot always be looked upon as an etiologic factor, although it is quite possible that minor traumata, unnoticed by the patient, such as a frequently repeated movement, may play a part in the etiology of ganglia.

Ganglia appear most commonly on the dorsal surface of the wrist (Fig. 126), but they may arise from any of the connective tissues in the body. They are not at all uncommon on the palmar surface of the wrist, along the flexor tendon sheath of the distal palm and the proximal portion of the finger, over the dorsal surface of the distal phalanx of the finger (Fig. 127) and the toe, along the tendons inserting on the head of the fibula, over the dorsal surface of the foot (Fig. 128) and, rela-

tively more uncommon, in the connective tissue of the scalp, of the tendons themselves (Fig. 126, *right*) and along the nerves.

Symptoms. The symptoms produced by ganglia vary considerably with their location The most prominent and constant symptom is the presence of the mass, this is easily visible when it appears subcutaneously on the wrist or the finger. At times the swelling is a smooth rounded mass; at others, it is multilocular. The ganglia vary in consistency; they usually are hard and firm, frequently diagnosed as bone or cartilage, but they may be cystic and definitely fluctuant. This probably depends upon the stage of development at which the ganglion is seen There often is variation in size, increasing after excessive movement or use of the part and decreasing with rest.

Pain frequently is a symptom; it may be dull and constant in character, or it may appear following the use of the affected part. Pressure upon the ganglion may give definite sharp pain. This is particularly true of ganglia appearing on the flexor tendon sheaths in the palm, where grasping a hard object causes extreme pain There may be an associated weakness of the area involved by the ganglion, such as the wrist, the finger or the toe.

Treatment. The indications for treatment of ganglia are three in number: (1) The desire of the patient for removal of the unsightly mass produced by the ganglion, (2) relief of the feeling of weakness of the part; and (3) relief of the pain or the soreness.

Five methods have been used in treating ganglion—rupture, aspiration with or without injection of sclerosing solutions, excision, roentgen irradiation and hydrocortisone injection.

RUPTURE

Rupture with dispersion of the contents of the ganglion has been regarded as the most conservative method of treatment. This is accomplished by striking the ganglion sharply with a heavy object, usually a book, or by finger pressure. This method is applicable only to ganglia which may be made prominent, such as those on the dorsum of the wrist. No anesthesia is required. After the ganglion is ruptured, the area is massaged so that the gelatinous contents may be dispersed and absorbed in the surrounding subcutaneous tissues. Recurrence may take place, but since a cure is obtainable by simple rupture in at least one half of the cases, this conservative treatment would seem to be worth at least one trial. Our experience with rupturing in 32 cases showed a permanent cure without recurrence in 16, or 50 per cent. In 10 other cases, we were unable to produce rupture, and excision was performed.

ASPIRATION

The treatment by aspiration of the ganglion contents has been disappointing. In many cases the content of the ganglion is of such a firm, jelly-like consistency that aspiration is unsuccessful. In other cases, the multilocular character of the ganglion has made it difficult to be certain that the contents were entirely evacuated, even though some of the gelatinous material could be removed. When aspiration is attempted, a large-bore 14-gauge 1-in needle should be employed. Attempts to remove the gelatinous material with smaller needles usually are unsuccessful

After all the material has been aspirated, the syringe is removed and

the needle is left in place for injection of a sclerosing solution. Sarma[47] recommends using a 5 per cent sodium morrhuate solution or 5 per cent sodium psylliate. Only a small amount of solution should be injected, as a rule, not more than 1 cc. McEvedy[31] has followed 13 patients treated by injection 13 years ago. Eight still have a swelling (18 per cent). He injects sodium morrhuate, usually 1 or at most 2, injections are required. The injections produce moderate pain and local edema lasting a day or two, but the therapy usually is not disabling. Personal experience with aspiration and injection has not been favorable, except in those cases in which the material in the ganglion is more liquid than that generally found.

Excision

The most successful method of treatment has been careful dissection and excision of the ganglion. Whenever possible, a tourniquet is used to produce a bloodless field. This permits a more rapid and accurate dissection. The operation may be performed under local-infiltration anesthesia of 1 per cent procaine hydrochloride. With strict aseptic precautions and retraction to keep the sides of the wound on tension, the ganglion is separated from the surrounding tissue by blunt and sharp dissection. At its base it is wise to excise a fairly generous amount of the surrounding tissue; this is the best insurance against recurrence.

If the capsule of the joint or the tendon sheath is opened, no effort is made to close it. After the closure of any dead space, the skin is sutured with vertical mattress stitches. A firm compression bandage is applied, and the part is splinted when possible. The patient is ambulatory throughout treatment. With this type of therapy, we operated upon and followed 18 patients with complete removal and cure of 15, or 83.3 per cent. There was a recurrence in 3 cases, or 16.7 per cent. Of the recurrences, 2 were cured by subsequent rupture, 1 by excision.

It is wise not to promise that there will be no recurrence after the removal of a ganglion. Even wide excision of the surrounding tissues may not prevent the same process from recurring with the formation of another ganglion.

Irradiation therapy has given good results for ganglia of the hand and the wrist, according to Lyle[29] and Reeves.[41] They treated both new swellings and recurrences, aspirating the ganglion before treatment if it was 1 cm. in diameter or larger. Monthly treatments of from 100 to 500 r. were given, the average number of treatments required was three. They postulate a "fibrosis and destruction of the endothelial secreting cells" by irradiation, and they obtained cures in about 80 per cent of their cases.

Hydrocortisone has been used in the treatment of ganglia. Hydrocortone, 25 mg. per cc. in saline solution, is injected in amounts of from 0.3 to 0.5 cc. directly into the swelling without anesthesia or aspiration. Becker[3] claims that a single treatment is successful in most cases, but 2 or 3 injections at weekly intervals may be necessary. He reports excellent results in 87 per cent of 30 cases.

BURSAE

Pathology. Bursae are potential spaces developed in connective tissues. They contain a synovial-like fluid which permits movement of one tis-



Fig. 129 Acute traumatic olecranon bursitis (Kaplan Louis, and Ferguson, L Kraer Am J Surg 37:155 165)

sue over another with a minimum of friction It has been shown very definitely that bursae are developmental in origin and that they appear in the connective tissue in response to a functional demand In 1931, Black[4] examined a large number of fetuses and showed that only the subacromial bursa was present at birth, and thus he was able to identify as such in 72.5 per cent of the specimens Neither the commonly found subcutaneous olecranon nor the prepatellar bursa was present at birth, therefore, one is forced to the conclusion that they develop after birth in response to movement. One could conceive this development as a prolongation and a fusion of the intercellular spaces in the plane of motion, the bursal space itself representing an intercellular space between layers of connective tissue cells, with the bursal fluid as liquid intercellular matrix.

Cells of bursal and tendon sheaths do not differ in any marked degree from those of joint synovial membranes, and a joint cavity, according to studies of the cell structure, appears to be a local modification of a specialized connective tissue, the synovia, in which the intercellular matrix is very fluid.[25]

In the formation of the subacromial bursa as followed in fetuses, Black states that "connective tissue of a fairly circumscribed area undergoes certain changes to form a fairly definite anlage composed of large, moderately closely packed cells which are arranged more or less parallel to the long axis of the future bursa. Slits appear between the cells and merge or remain adjacent. These slits extend throughout the bursal anlage, but stop at the border of the undifferentiated connective tissue. The early slits develop into a definite cavity lined by swollen, characteristic cells. When the cavity attains a certain size, the lining cells disappear and the cavity comes to have a lining of ordinary, but specially arranged, fibroblasts and other connective tissue elements."

Trabeculae seen in otherwise normal bursae may then be regarded simply an intervening septa or folds between bursal slits in the same plane which have not undergone fusion, and not necessarily as pathologic adhesions between apposed surfaces.

Bursae may be divided into two groups, the superficial and the deep Superficial bursae are those which lie in the connective tissue between the skin and bony prominences. Those which most often are found to produce symptoms are the olecranon, the prepatellar bursa and the bursa over the head of the metatarsophalangeal joint of the great toe. The deep bursae are those which lie between muscle and moving body points. The most important of these is the subacromial or subdeltoid bursa; less often the

bursa over the greater trochanter of the femur or over the tuberosity of the ischium may give symptoms.

DISEASES OF THE SUPERFICIAL BURSAE

Superficial bursae, those which develop in response to long-continued or repeated friction between the skin and bony parts, may assume definite pathologic changes due to trauma or infection.

Acute Traumatic Bursitis

Etiology. Ordinarily, the application of external violence over a superficial bursa—for example, the olecranon bursa—results in a sliding of the skin over the triceps tendon and the olecranon process. If, however, the violence is such that contusion or tearing of the bursal surface occurs, hemorrhage and exudation take place. The bursa, previously only a potential space, fills with serosanguineous fluid and becomes a palpable, well-defined fluctuant sac over the point of the elbow (Fig. 129). From a distended bursa, a characteristic viscid bloody, or later, straw-colored fluid may be aspirated.

The fluid tends to be absorbed when the acute reaction subsides, but varying amounts of cellular elements and fibrin remain and undergo organization. This results in thickening and roughening of the bursal wall, and perhaps adhesions between apposed bursal surfaces. After a single trauma, the residual thickening may be so slight as to cause no palpable changes. Persistent return of fluid into the bursal space following an acute bursitis probably is due to friction between the apposed roughened surfaces on return to motion.

Symptoms. The symptoms of acute traumatic bursitis are easily recognized. There is a history of a trauma applied to the affected bursa with subsequent tenderness and distention of the bursal sac. It is somewhat important in making the diagnosis to ascertain whether the lesion is an acute traumatic bursitis superimposed upon a chronic process, or whether the trauma has been applied to an otherwise normal bursa. It is important to make this differential diagnosis because of the difference of prognosis and of treatment.

Treatment. An acute traumatic lesion in a previously normal bursa receives the same treatment as any other acute traumatic lesion. Immobilization of the part prevents further injury, decreases pain and causes the acute symptoms to subside rapidly. An internal right-angled splint for olecranon, and a posterior knee splint for prepatellar, bursitis serve very well. A firm elastic compression bandage applied to the part tends to decrease the swelling and aids the immobilization. In the first 24 to 36 hours, cold applications help to relieve the pain and perhaps lessen the exudation.

When there is distinct fluctuation in the bursa, aspiration relieves the tension and hastens recovery. The aspiration may be performed easily under local infiltration anesthesia through an 18- or 20-gauge needle. After removal of the fluid, a pressure pad or bandage is applied over the collapsed bursa. As a rule, what little residual pain is present may be relieved by mild analgesics such as salicylates.

After the acute exudative phase subsides, usually in 2 or 3 days, heat may be of value. Hot-water bottles, infrared lamp, the radiant baker or hot wet applications, used for 15 to 30 minutes

3 times daily, help to shorten the period of recovery. At times the fluid recurs following aspiration, but in smaller amounts; this usually is absorbed spontaneously. Splinting need be continued for only 3 or 4 days, but a pressure bandage of elastic adhesive has been found to be useful for longer periods. Care should be taken to protect the area of the bursa against subsequent trauma.

Subacute and Chronic Bursitis

Etiology. When the trauma is relatively mild but occurs frequently, or when the resorptive phase of an acute bursitis is interrupted repeatedly by further trauma, fibrous-tissue formation becomes the preponderant characteristic. The bursal walls become much thickened, trabeculae and villi form, increase in number and density, and fill the space. These trabeculae may represent thickening of the septa or folds commonly seen in healthy bursae, or they may be stretched-out adhesions between the bursal walls. The villi arise as granulations in the floor of the bursa. The granulations tend to grow into the cavity of the bursa, so that eventually polyplike projections form. These consist of a central vessel surrounded by a stalk of fibrous tissue. The villi frequently have bulbous tips (Fig. 133, inset). Small amounts of fluid also are present. Thus, that which in the very mild subacute form may be clinically evident as a slight palpable thickening of the bursa may in the advanced chronic form become a large rubbery mass in the subcutaneous tissues containing numerous hard movable bodies.

Frequently, the causal factor in the development of a chronic thickening of the bursal wall is occupational, the patient's work necessitating exposure of the bursa to continued trauma. The occurrence of a chronic bursitis in certain occupations is so common as to have given characteristic names, such as housemaid's knee (chronic prepatellar bursitis), miner's elbow (chronic olecranon bursitis) and so forth. The continued trauma of a shoe to the bursa over a projecting first metatarsophalangeal joint is another similar instance.

Symptoms. In a few cases, patients with a chronic bursitis complain of a sharp pain when slight trauma is applied over the bursa. Thus, patients describe a feeling of the elbow's having been put down on a tack when a hypertrophied villus or trabecula is traumatized by leaning on a hard surface with the elbow. In the case of chronic prepatellar bursitis, similar pain is experienced when kneeling. When these bursae are examined, the bursal sac may be outlined as a thickened, rubbery area containing small, hard, tender and usually movable bodies. These bodies, which are formed by villi springing from the bursal floor, are often so hard as to be confused with bone. When traumatized, they become so tender that pressure causes sharp pain. If the bursa can be protected from trauma over a sufficient period of time (3 or 4 weeks), the chronic induration in the bursal wall may subside and the acute traumatic inflammation in the villi disappear so that the bursa is no longer painful. When it is impossible to protect the bursa from repeated trauma, excision is necessary.

By far the largest number of patients with chronic bursitis seek treatment following a recent acute trauma. In such cases, there is really an acute bursitis superimposed upon a chronic



FIG. 130. Prepatellar bursa before and after 2 aspirations and injections of Carabba's solution. The follow up result was taken 4 weeks after the initial treatment. (Kaplan, Louis, and Ferguson, L. Kraeer Am. J. Surg. 37:155-165)

bursitis. The bursal sac is distended and fluctuant, but, on palpation, the indurated walls of the bursa are noted easily and the fibrous trabeculation and villi can be rolled under the fingers. Aspiration of fluid from such a bursa usually results in a rapid and almost complete refilling in a period of from 24 to 48 hours, and applications of heat or pressure have little effect, even though applied for several weeks.

Treatment. In the treatment of this type of bursitis, two methods of approach are available. In one, an effort is made to obliterate the sac completely by injecting some irritating solution into the bursal cavity after aspirating the fluid in it By this method of therapy, the sac becomes a firm fibrous scar in the subcutaneous tissue. Various substances have been used for injection. Eising[16] suggests sodium morrhuate, 5 per cent solution, such as is used for the injection of varicose veins. From about 0.75 to 1 cc. may be injected into the space after aspirating the fluid, then a pad, a pressure bandage and a splint are applied. When successful, the bursa is obliterated and, with motion, a new bursa probably forms. Carp[10] had excellent results with the injection of 2 to 5 cc. of 3.5 per cent tincture of iodine. In about half of his cases there was reaccumulation of fluid in the bursa; this was aspirated. A cure was obtained in 24 of 27 cases. Sodium psylliate may also be used in amounts of 1 to 2 cc.

Carabba,[9] after injecting 2 to 3 cc. of 2 per cent procaine solution into the bursa for anesthesia, injected 1 to 3 cc. of a sclerosing solution (p. 17) and then applied a pressure bandage (Fig 130). When necessary, the bursa was reinjected at the end of 2 weeks.

Burgess[7] has accomplished the same result by a subcutaneous incision of the bursal walls. After procaine is injected into the skin and the bursal sac, a small knife is used to incise the wall of the bursal sac so that its cavity drains into the subcutaneous tissues. A pressure dressing is applied and active motion is permitted. This method of therapy gives good results in chronic olecranon and prepatellar bursitis (Fig. 131).

When conservative treatment fails

to give relief, operation must be considered.

When the prepatellar or the olecranon bursa has become very much thickened and protuberant (Fig. 132), conservative treatment offers little prospect of relief, and excision should be advised (Fig. 133).

Local anesthesia by infiltration of the tissues surrounding the bursa with 1 per cent procaine hydrochloride is satisfactory if care is taken to inject beneath the bursa so that its dense attachment to the underlying structures is rendered insensitive. The incision should be made away from the projecting point of the joint longitudinally. It is sometimes possible to remove the sac intact by combined blunt and sharp dissection. It will be found that the floor of the bursa is attached densely to the underlying

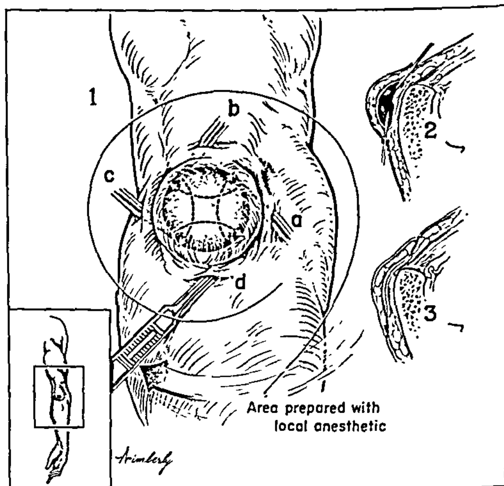


FIG. 131 Burgess method of treatment for chronic superficial bursitis. After infiltration round and at the edge of the bursa, a pointed knife is inserted at each of 4 puncture sites and swept round in an arc to separate the roof from the floor of the bursa. Very slight bleeding can be controlled by a pressure dressing. The bursa becomes obliterated by the formation of a scar as the roof and the floor of the bursa grow together.



Fig. 132. Extremely hypertrophied prepatellar bursa on amputation stump. This bursa was excised under local anesthesia; note the thickness of the bursal wall in the excised specimen.

Fig. 133. Excision of a chronic, thickened olecranon bursa. Note the position of the patient on the table and the location of the incision to avoid the tip of the elbow. Inset shows the inside of the bursa with bulbous villi in its cavity. (Kaplan, Louis, and Ferguson, L. Kraeer: Am. J. Surg. 37:455-465)

tendon and periosteum, and sharp dissection is therefore necessary. Frequently, the periphery of the bursa is thin and breaks through, and the removal is effected piecemeal. The dead space is closed and the wound is sutured loosely. A good result depends on obliteration of dead space in the wound. To this end, an elastic pad and a firm bandage are applied over the wound, and the part is splinted. Serosanguineous drainage may be somewhat persistent and need not be interpreted as a result of incomplete excision. The application of dressings saturated in 70 per cent alcohol is the most effective method of treating these wounds. It is rarely necessary to remove sutures for drainage of accumulated serum Healing usually is otherwise uneventful

Excision of the bursa alone in the bursitis accompanying hallux valgus is of little value The hallux valgus requires operation in order to secure relief.

Suppurative Bursitis

Etiology. Suppurative bursitis may follow a laceration or a puncture of the skin overlying the bursa, or it may be the result of extension from a contiguous infection. Furuncles over the patella frequently extend to involve the prepatellar bursa.

Treatment. Seen early, these cases are best treated conservatively. Splinting reduces pain and minimizes tension, rest and hot wet dressings are used; and no operation is performed until the inflammatory process becomes well localized. Incision and drainage should be performed under general anesthesia, the bursa and its pockets being laid wide open and packed with gauze to maintain good mechanical drainage. Splinting, hot wet dressings and rest are continued until complete subsidence of the infection has taken place. The associated cellulitis will usually subside with this therapy, but it may be hastened by the use of penicillin systemically. Unless there is obvious reason, because of persistent pain or fever, to suspect a complication, the dressings are left undisturbed for 4 or 5 days; then the packing is removed and simple dressings are applied. Antiseptics are not introduced into the infected wound.

Drainage, particularly when the bursa has previously been thickened and contains numerous trabeculae, may continue over a prolonged period, but the wounds usually close without special treatment.

No attempt should be made to excise an acutely inflamed bursa.

Occasionally, a suppurative bursa, having been incised, will continue to drain and not close with conservative therapy. In a few of these cases, cauterization of the open tract with phenol or Carnoy's solution (p. 17) results in a cure; if this is unsuccessful, excision of the bursa is necessary to permit permanent healing.

Diseases of the Deep Bursae

The deep bursae are those which lie between muscle and moving bony projections. Those most commonly found to give symptoms are the following: (1) subacromial, between the coraco-acromial arch and the deltoid muscle above, and the short rotators of the humerus and the greater tuberosity below; (2) subgluteal, between the femoral greater trochanter and the gluteus maximus muscle; (3) iliopsoas, between the capsule of the hip joint and the iliopsoas muscle; (4) supratrochanteric, in the muscle planes

above the greater trochanter; (5) semimembranosus, between the tendon of the semimembranosus muscle and the inner head of the gastrocnemius. (6) pretibial, between the quadriceps tendon and the tubercle of the tibia.

Numerous other deep bursae exist in areas in which muscles overlie moving bony points, but they cause symptoms so rarely that they are not mentioned specifically.

The deep bursae, lying as they do between bony points and muscles and being almost constantly utilized in movements of the various parts of the body, often undergo chronic changes with advancing age. Changes which produce roughening of the bursal surfaces, calcification in or about the bursal wall or trauma may cause pain, weakness and limitation of the movements involving the bursa.

Acute Traumatic Bursitis

Etiology and Symptoms. Acute traumatic bursitis of the deep bursae is a comparatively common lesion, especially of the subdeltoid bursa. The bursitis may follow direct or indirect trauma. The symptoms produced by acute deep bursitis are pain on movement of the part for which the bursa provides a gliding surface. In less acute inflammations, there may be simple weakness of the part with tenderness over the bursa and, occasionally, a perceptible swelling. In severe traumas, there may be sufficient irritation to produce muscle spasm and almost complete loss of function of the muscles and the parts surrounding the bursa. The pathologic process is essentially identical with that following acute trauma to a superficial bursa, and the treatment is, in principle, the same as that for any other acute traumatic lesion.

Treatment. Immobilization is instituted for at least 2 or 3 days, tension and pressure in the bursa being relieved so far as possible. Local heat or diathermy is of value in this stage. After the acute symptoms have subsided, gradual resumption of normal function may be permitted. Mild analgesics may be necessary during the first 24 to 48 hours after acute trauma.

Acute Nontraumatic Bursitis

Chronic degenerative changes in the bursal wall and in the tissues and the tendons surrounding the bursa may produce acute and chronic symptoms. These are pain and disability during those movements which require one bursal surface to glide on the other. The bursa which shows the most changes and produces the most symptoms is the subacromial or subdeltoid bursa. The symptoms and the treatment of its various lesions are discussed in more detail in Chapter 22. The symptomatology and the treatment of the diseases of the various individual bursae are described in the chapters on regional surgery.

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PART TWO

REGIONAL SURGERY

13

The Scalp

From the surgical point of view, the scalp may be considered as composed of the outer 3 layers of the covering of the skull. The outermost layer is the skin, which in this region is very thick. It is richly supplied with sweat and sebaceous glands and with hair follicles. The subcutaneous tissue is composed of a dense network of connective tissue fibers, by which the skin is firmly attached to the underlying galea aponeurotica. These fibers form ill-defined septa enclosing small fat lobules and a rich network of blood vessels (Fig. 134). The vessels are so firmly fixed in this fibrous tissue layer

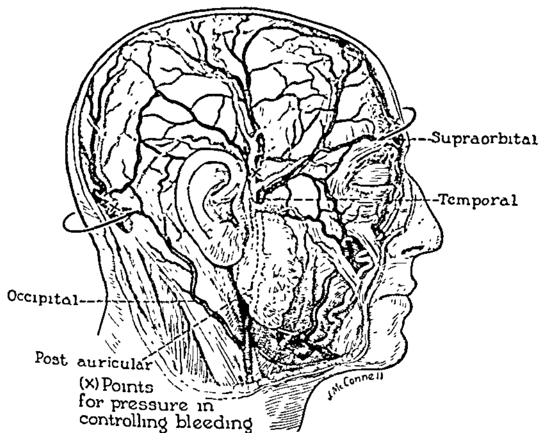


FIG. 134. Vessels of the scalp of surgical importance. Note sites of pressure to control bleeding. An elastic (rubber-tube) tourniquet placed round the scalp above the ears at the site of the arrows will control bleeding effectively from the portion of the scalp above the tourniquet.

that they are unable to contract fully when they are cut. This accounts for the profuse bleeding often seen in even minor scalp wounds.

The epicranius, or occipitofrontalis, muscle and its aponeurosis form the innermost layer of the scalp proper. It is composed of a thin layer of muscle at its origin along the superior curved line of the occiput and at its insertion in the bone and soft tissues above the orbit. Between these muscular portions lies a well-defined aponeurosis (galea aponeurotica). This structure is separated from the pericranium by a layer of loose connective tissue, which permits considerable movement of the scalp proper over the skull.

The vessels of surgical importance are the supra-orbital, the temporal, the posterior auricular and the occipital arteries (Fig. 131). These anastomose freely and provide the scalp with a blood supply so efficient that even large skin flaps will heal and infection from traumatic wounds rarely occurs unless there is gross contamination or tissue destruction.

Since the entire blood supply comes from below toward the vertex of the scalp, a snug rubber band round the scalp above the ears is an effective tourniquet to control scalp bleeding during operations or until surgical suture of scalp wounds is accomplished.

The lymphatic drainage from the scalp is downward to the regional glands. If the scalp is divided by an imaginary line from ear to ear, the drainage from the scalp posterior to that line is into the postauricular and the occipital nodes. Anteriorly, the drainage is into the preauricular and the submaxillary nodes. An adenitis, especially of the nodes anterior and posterior to the ear, should call attention to a primary infection in the scalp.

LACERATIONS AND CONTUSIONS

Injuries to the scalp usually occur through falls or blows by blunt instruments. In spite of this, the wounds produced are usually clean cut because of the firm underlying bone over which the scalp is stretched. When only the superficial skin is severed, there is little tendency for the skin to gape because it is held so firmly in place by the underlying fibrous tissue septa. Wounds which divide the galea, if made in an anteroposterior direction, tend to separate only slightly. In wounds made transversely across the skull, on the other hand, the muscular portion of the deep layer of the scalp becomes apparent; the wound edges pull apart and often turn under. Wounds of the scalp bleed profusely because of the rich blood supply and the inability of vessels to contract and retract due to their being firmly embedded in the dense fibrous subcutaneous tissues. Temporary control of bleeding can easily be obtained, however, by firm pressure on the underlying bone. The head dressing (Fig. 70) is a most effective dressing to produce continued pressure.

Treatment. In caring for wounds of the scalp, enough hair should be cut away to permit a good exposure of the wound. If small sharp scissors are used, the hair usually can be cut close enough so that shaving is not necessary. During this procedure, pressure upon sterile gauze in the wound will afford protection and control bleeding. The surrounding area should first be cleaned with green soap and sterile water, then the wound should

be washed thoroughly with the same solutions, care being taken to remove all foreign materials. All flaps or irregular edges should be carefully cleaned up and preserved because scalp wounds heal kindly, in spite of considerable trauma and gross contamination.

The simplest and the most effective method of controlling bleeding and closing a scalp wound is by suture. This can easily be accomplished under local anesthesia introduced through the edges of the wound. Bleeding, which may frequently flood large wounds so that careful suture is difficult, may be controlled relatively easily by grasping the galea with hemostats. When the hemostats are turned back from the wound, the dense galea compresses the vessels so that bleeding is negligible. The sutures are best inserted with curved, cutting-edge needles, silk, cotton or fine wire sutures being used. Alternate vertical mattress and simple interrupted sutures produce the best approximation and, at the same time, the most adequate control of bleeding (Fig. 135). The deeper part of the mattress suture should include the galea, the interrupted sutures need pass only through the skin and the subcutaneous tissues. If hemostats have been applied to control hemorrhage, suturing should begin at one end of the wound, and the hemostats should be removed one by one as the sutures are placed.

Drainage is rarely necessary in scalp wounds. If the wound has been given a thorough mechanical cleansing, infection is rare. If it is seen early, it is even safe, in a relatively clean wound, to seal it with a cocoon of Whitehead's varnish and fluffed cotton (Fig. 138). Large wounds and those with some continued oozing are dressed more efficiently with a pressure head dressing. Traumatic wounds should be inspected frequently for signs of infection during the first few days after suture. If wounds are seen late, bleeding is not a serious factor and the possibility of infection makes snug suture unwise. Loose approximation with adhesive strips is permissible, or loose sutures may be inserted.

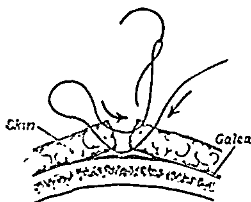


Fig. 135. Vertical mattress suture of the scalp. The deeper suture passes through the galea and the superficial through the skin edges.

HEMATOMAS

Etiology and Diagnosis. Hematoma of the scalp is a relatively common lesion resulting from a blow on the head which does not produce a skin wound. The injuries which produce a rupture of the vessels of the subcutaneous tissues may be looked upon as simple contusions. Usually, bleeding is not very extensive because of the density of the tissues, and spontaneous absorption will occur with pain of only 24 to 48 hours' duration. A definite hematoma results when the trauma causes a tear in the galea. Bleeding can then take place into the loose subaponeurotic tissues and may extend for a considerable distance in this space. The lesion is characterized

by a rapidly appearing swelling which at first is soft and fluctuant but within a few hours takes on its characteristic appearance. A center of soft, pulpified tissue and blood is surrounded by a hardened ring composed of clotted blood and inflammatory induration. The ring often is so dense as to be mistaken for a ring of bone surrounding a depressed fracture of the skull. The accompanying symptoms are usually of such minor nature as to rule out this latter diagnosis, but, if there is any doubt, a roentgen film should be made and bed rest with careful observation enforced.

Treatment. The treatment of a hematoma of the scalp is conservative. As a rule, spontaneous absorption will take place. Aspiration is not often successful until late, when in rare cases the clear, straw-colored serum may be aspirated from a pseudocyst. Occasionally, slow necrosis of the overlying skin may occur due to the contusion of the causative blow. In such cases, spontaneous drainage occurs. Infection in a hematoma rarely occurs unless there is a coexistent scalp infection. When infection is present, as evidenced by pain, swelling and increased heat, incision and drainage must be performed. This can be done under local anesthesia after adequate preparation of the field by cutting away the surrounding hair. Plain gauze or iodoform gauze packing may be inserted into the wound and left in place for from 3 to 4 days. After 12 hours, hot boric acid solution may be applied to the dressing. The head dressing is the simplest method of holding compresses in place (Fig. 70).

ABRASIONS

Abrasions of the scalp are rare. When they do occur, it is well to treat them with respect because of the danger of secondary cellulitis. Sufficient hair should be cut away to expose the injury, and the abrasion should be cleaned carefully with green soap and water, a soft gauze sponge being used as a mop. One of two methods of dressing may be chosen:

If the abrasion is seen early and can be cleaned easily, tannic acid 5 per cent compresses or spray may be used to hasten the sealing of the wound; in abrasions seen late, Aureomycin ointment dressings are preferable. In either case, frequent careful inspection of the area should be practiced to detect any evidence of infection at the earliest possible moment. If redness and local pus appear, warm wet dressings are applied.

INFECTIONS

All wounds of the scalp which are first seen after the period of invasion (6 to 8 hours) has passed should be looked upon as potentially infected wounds. They should be cleaned as carefully as posssible with green soap and water and closed loosely with fine wire sutures or adhesive. Antibiotics are used as a prophylactic measure. If the wounds are frankly infected, they should be treated with hot wet dressings and permitted to heal by secondary intention. The presence of a scar on the scalp is not disfiguring if it can be covered with hair. Late suturing of scalp wounds is not recommended because too often a scalp infection results.

Cellulitis

Cellulitis of the scalp, like cellulitis elsewhere in the body, is usually due to the streptococcus. The diffuse, pain-

ful, tender redness, with edematous swelling of the skin and the subcutaneous tissues characteristic of cellulitis, most often occurs secondary to an abrasion or a wound, although the infection may appear without any visible primary lesion. If the infection is extensive, constitutional symptoms may be present.

Treatment. As a rule, the cellulitis may be expected to subside with the use of antibiotics. Occasionally, subcutaneous necrosis may result in a subcutaneous abscess; this will require incision and drainage under local anesthesia. Penicillin by injection or by mouth or the broad-spectrum antibiotics (see Chap. 7) will be helpful in the control of the infection, and by its use abscess formation may be avoided.

Furuncles

Etiology. Furuncles of the scalp are less common than those of the neck, where friction against the collar is a causative factor. Nevertheless, they occur not infrequently from infection of the hair follicles of the scalp. They are often multiple. They are seen in those in whom the scalp has received little hygienic attention, and more often in children than in adults. The wonder is that furunculosis does not occur more often. The appearance of the lesion is typical. Frequently, regional lymph nodes show a tender swelling.

Treatment. The treatment of furunculosis of the scalp is usually conservative. As a rule, these infections respond well to systemic antibiotic therapy. Generally, penicillin is tried first, but if the infection appears to be resistant to this drug, sensitivity tests should be made of a culture of the organisms to determine the appropriate alternate drug.

Carbuncles

Carbuncles of the scalp are seen most often in the region of the occiput, but they may occur in any area of the head. The staphylococcal infection, which may begin as a simple furuncle, extends very slowly in the dense subcutaneous tissues. The numerous fibrous septa produce a marked symptom.

Treatment. The treatment of carbuncles has been discussed (p. 121). The antibiotics – usually penicillin – have largely taken the place of surgery. Occasionally mechanical removal of the dead tissue with forceps and scissors will hasten the process materially. If excision or incision is performed, skin grafting may often be used to hasten closure of the defect.

Subaponeurotic Abscesses

Infections of the subaponeurotic space are potentially more dangerous than those of the superficial layers of the scalp because of venous channels which lead from this space through the bone into the intracranial venous sinuses. There is thus the possibility of an extension of the infection to the skull or to the intracranial venous channels. Infections in this space may occur by contiguity from more superficial infections, but more often they occur as a result of implantations from injury or as a secondary infection of a hematoma.

Treatment. Incision and drainage are the indicated procedure. As a rule, an anterioposterior incision is preferable, with counter incisions at dependent areas if the abscess extends over the sides of the head. Appropriate antibiotic therapy is used in addition.

Erysipelas

Etiology and Diagnosis. The scalp is not uncommonly the seat of erysipelas, usually as an extension from a primary facial infection; occasionally, however, the infection may begin in the scalp itself. On the hairy surface it may be somewhat difficult to identify the raised, tender edge of the infection, but the acute tenderness and the extension from a pre-existing facial erysipelas make possible a correct diagnosis. The associated cellulitis often leads to subcutaneous necrosis and abscess formation, as is typical with other streptococcal lesions.

Treatment. The treatment of erysipelas has been discussed on page 127. There is nothing characteristic about erysipelas of the scalp, but bed treatment generally is necessary because of the accompanying toxemia Penicillin therapy usually gives good and immediate control of the infection. When localized necrosis leads to abscess formation, incision and drainage may occasionally be performed as an ambulatory measure.

Dermatologic Infections

A surgeon may be called upon to treat conditions which are the result of various infective dermatologic lesions. Lymphadenopathy, for instance, may be produced by impetigo, ringworm, eczema and various types of dermatitis. These lesions are mentioned only to point out that, though they are pus-producing conditions, surgical therapy is rarely necessary. Conservative dermatologic treatment will not only heal the lesion itself but also cause subsidence of the lymphadenopathy. Such treatment consists of cleansing with tincture of green soap, followed by various ointments, antibiotics or roentgen irradiation.

There is one other infection of the scalp which should be mentioned in this connection because of the fact that it frequently is an unrecognized cause of postcervical adenitis. This is pediculosis. There may be almost no evidence of excoriations. One frequently encounters patients in whom a variety of erroneous diagnoses were made in explanation of the persistent adenopathy through failure to examine the hair carefully for the telltale nits. Eradication of the head lice by an overnight application of equal parts of olive oil and kerosene produces remarkable results, and solution of the nits may be accomplished by rinsing the hair with vinegar. Under this therapy, the unexplained adenopathy probably will disappear in a short time. (See p. 151 for outline of treatment with DDT powder.)

SEBACEOUS CYSTS

The scalp is the most common location for sebaceous cysts. (See Chap 12.) They are frequently multiple and may vary in size from hard nodules smaller than a pea to large egg-sized masses (Fig. 136).

Etiology. Sebaceous cysts are examples of the retention type of cyst. They are caused by an obstruction of the duct outlet by a dry, hard mass of sebaceous material. The cyst usually results from a gradual distention of the ducts leading from the alveoli of the compound gland. It is, of course, attached to the skin at the outlet of the duct, and, in the scalp, it lies in the subcutaneous tissues above the galea. It is freely movable over the underlying tissues, and the skin can be moved over it except in the area about the duct outlet.

The cysts usually give rise to very few symptoms, though they are dis-



Fig. 136 (*Left*). Sebaceous cyst of the scalp

Fig. 137 (*Center*). Type of sebaceous cyst of the scalp which is confused easily with a lipoma.

Fig. 138 (*Right*). Whitehead's varnish dressing following excision of a sebaceous cyst. The sutured wound is painted with the varnish and then wisps of cotton are placed over it. The wound and the cotton are cemented together with another application of varnish When this dressing dries, it becomes firm and hard, and acts as an excellent splint for the wound. It may be removed simply by pulling upon it, often because the sutures are a part of the cocoon they may be clipped as the varnish is removed so that splint and sutures are removed together.

figuring and frequently cause annoyance in combing the hair or in wearing hats (Fig. 101).

Diagnosis. Dermoid cysts are not found on the hairy portion of the scalp; therefore, the diagnosis must be made as to whether they are sebaceous cysts, lipomas of fibrolipomas. Usually this is easy, but at times it may be confusing, especially when the mass is found in the scalp on the back of the head, where both lesions commonly occur (Fig. 137). The chief points of difference are:

Sebaceous Cyst

Attached to skin at one point
Moves over underlying tissues
Sharply defined, smooth, hard surface

Lipoma

Not attached to skin
Moves with difficulty over underlying tissues
Ill defined, irregular lobulation, softer surface

It is important to diagnose these lesions correctly because the shelling out of a sebaceous cyst is usually a simple matter, whereas the removal of a lipoma is often comparatively difficult and requires at least one assistant.

Complications. Sebaceous cysts may be complicated by infection or by

malignant degeneration. Infection is by far the more common complication and is often the reason why treatment is sought. When the cysts become infected, they enlarge rapidly and become red, painful and, in from 24 to 48 hours, more definitely fluctuant. Usually the infection so distends the cyst that subcutaneous rupture occurs in 2 to 3 days; thus a local subcutaneous abscess partly in the cyst and partly in the subcutaneous fatty tissue is formed.

Malignant degeneration of sebaceous cysts occurs very infrequently. From experience with more than 1,000 patients with this lesion, a large proportion of them with multiple cysts, the author has seen carcinomatous degeneration in only two. This low incidence of malignancy is at variance with Caylor's[1] figures of 3.41 per cent. Malignant degeneration occurs almost always in patients in the late fifth and in the sixth decades and in cysts which have been present for many years. The cyst shows at first a definite hardness, loses its movability in the tissues, and then progresses to an ulceration. Those on the back of the scalp are more prone to this degeneration.

Treatment. The indications for treatment of sebaceous cysts are to rid the patient of the disfiguring or bothersome mass or, more important, to avoid the frequent complication of infection or the less frequent possibility of malignant change. The treatment of simple sebaceous cysts is excision by enucleation.

In preparation for the operation, the hair should be shaved over the cyst and for a radius of about 1 inch round it (Fig. 104). Cutting the hair with scissors before shaving makes the process somewhat easier. The skin is prepared with 70 per cent alcohol in sufficient quantities to wet the hair round the cyst. This lessens the likelihood of long hairs falling into the operative field. After application of the drape, with its opening over the field of operation, a considerable amount of hair is exposed round the cyst. A supplementary field cover which has been found useful is made of three or four layers of loosely meshed gauze (Fig. 16). A hemostat or a finger can be pushed through the gauze between the meshes and the opening enlarged sufficiently to give a hole about 2½ or 3 inches in diameter. This can be placed so as to expose the cyst and the surrounding area of scalp; it makes an excellent small drape, not only in a situation such as this but also in others in which a small opening is desirable.

The field of operation is anesthetized with 0.5 or 1 per cent procaine containing about 6 drops of 1:1,000 solution of epinephrine hydrochloride per ounce of solution. The needle is inserted at the cyst's periphery, and the injection is carried along in the skin and the subcutaneous tissues to form a wall of anesthesia on the sides of the cyst and below it. The needle should never be introduced into an unanesthetized area after the first injection. Precaution in this respect will make the operation so painless that it can be performed on apprehensive adults and children (Fig. 105).

After anesthetic infiltration, the operation may be proceeded with immediately. In many cases, the duct opening may be seen easily and, when this is true, the incision should be planned so that it may be included in the elliptical bit of skin which is excised with the cyst. In smaller cysts, the duct opening often is not seen, and a single incision across the cyst is

all that is necessary. A successful excision of the cyst without rupture is the goal for which the surgeon strives and, to accomplish this, tension on the wound edges is most important. If an assistant is available, pressure down and away from the middle of the wound will permit the incision to gape widely as soon as the fibrous tissue layers over the capsule of the cyst are incised. The application of Allis forceps to the edges of the wound will then permit tension to be applied directly to the edges, and on some occasions the entire cyst may be exposed with no further dissection. As a rule, however, the dissection is not quite so simple. When the cyst wall is first exposed, it is best to dissect round the cyst capsule with a small hemostat and then to continue the incision upon the protecting hemostat. In this way the cyst wall is protected and the likelihood of opening the cyst is somewhat decreased. As soon as the line of cleavage between the cyst and the surrounding tissue is found, tension with one or several Allis forceps should be applied to the wound edges and the dissection continued with a curved mosquito hemostat in small cysts, and with a hemostat or blunt curved scissors in larger cysts. There is no necessity for any cutting in the operation for the excision of a simple sebaceous cyst. It usually shells out as a hard round mass. The combination of adrenalin in the procaine solution and tissue tension makes the operation almost bloodless.

When the cyst becomes large, the capsule becomes thinner and the likelihood of rupture is greater. In spite of this fact, most cysts can be removed without rupture if the operation is carried out carefully. Even if some of the cyst contents spill into the wound, it can be wiped out, and uneventful healing usually takes place. The wound is closed with mattress sutures which pass deeply to include the tissues in the base of the wound and come back across its lips. Such sutures produce excellent hemostasis, and no ligatures are necessary. Sutures should be silk, cotton or alloy steel wire, and they should remain in place for from 5 to 7 days. The most satisfactory covering of the wound is a Whitehead's varnish dressing (Fig. 138). (See p. 238.) This will remain in place with the hair combed over it and does not need to be replaced until time for the removal of sutures. This cocoon dressing is best removed by pulling it away in the line of incision without attempting to dissolve the varnish. Often the sutures can be removed as the cocoon is pulled away because the sutures form a part of it.

If numerous cysts are to be removed at one time, the field should be prepared for all of them before the operation is started. It is preferable to remove the smaller cysts first because there is less likelihood of bleeding from them and of consequent soiling of the hair and the scalp.

Nicholl[3] has suggested an ingenious conservative method of dealing with sebaceous cysts of the scalp. After infiltration with procaine solution over the cyst, a stab wound about ½ inch in length is made into the cyst. By pressure, the contents of the cyst are evacuated and wiped away. Then by kneading the area of the sac with a gauze-covered finger, the edge of the cyst wall is made to emerge at the wound. By gentle tension on the sac with forceps and continued kneading, the cyst wall may be removed intact. The wound is closed with Michel clips, and a pressure dressing is applied.





Fig. 139 (*Top left*). Papilloma of the scalp. This tumor was removed under local anesthesia in an ambulatory patient.

Fig. 140 (*Top right*). Papilloma of the scalp.

Fig. 141 (*Bottom left*). Lipoma of the scalp. Note the orange-peel appearance of the skin over the lipoma.

If the cysts become infected, they are first enlarged and distended and will then rupture into the subcutaneous tissues. Removal of such cysts often is difficult or impossible, and, as a rule, no attempt is made to enucleate them. A simple incision through the dome of the cyst is all that is necessary. After evacuation of the cyst and pus, it is often possible to see the outline of the cyst wall as a small localized area containing sebaceous material somewhat to the side of the pus pocket. It may be possible to remove the wall by sharp dissection. In other cases, the outline of the cyst is poorly defined, and successful removal usually cannot be made. In a few cases, destruction of the cyst wall by cauterization with pure phenol, followed by alcohol, may be successful. No attempt should be made to close the incision, the wound is packed with iodoform or simple gauze to control oozing. In at least 50 per cent of the cases, the cyst wall seems to be destroyed, by either cauterization or dissection, and recurrence does not take place. After the drainage of an infected cyst, the dressing mostly used is a Frazier head cap (Fig. 70) because usually it is impossible to apply a pressure dressing with adhesive on the scalp.

Carcinomatous degeneration in a cyst must be expected when, on operation, it is found to be firmly attached to the surrounding tissue and is not easily dissected. The hard character of carcinomatous tissue is quite easily noted and, in such cases, a wide excision rather than an attempt at enucleation is the preferable procedure. A fairly large elliptical piece of scalp may be excised and closure still effected, either by tension sutures or relaxing incisions on either side of the wound.

There is one other complication which occurs very infrequently in sebaceous cysts and that is calcification. These cysts, due to their woody hardness, may be mistaken for carcinoma. Because of this uncertainty, it is wise to perform excision rather than enucleation, as little harm can be done by excising a calcified cyst.

PAPILLOMAS

Papillomas of the scalp are relatively infrequent and rather troublesome lesions (Fig. 139). They are troublesome because the comb catches in them when the hair is being dressed. They vary between the size of a pea and the size of a walnut (Fig. 140), and are best treated by primary excision. The preparation described for operations on sebaceous cysts of the scalp (p. 230) is suggested for papillomas.

Not infrequently the scalp is the seat of wartlike growths. Usually they are small in size, but sometimes they are multiple and cause symptoms by being troublesome when the hair is being combed. Occasionally they bleed from trauma. They may be treated in one of two ways, either by excision to give a rapid and a permanent result or by electrodesiccation; both may be performed under local anesthesia. Dressings are necessary after excision but not after electrodesiccation Warts of the scalp do not tend to recur after excision or electrodesiccation, and for this reason they are easily and successfully treated.

TUMORS

Lipomas and Fibrolipomas

Diagnosis. The most common tumor of the scalp is the lipoma (Fig. 141). It may occur anywhere, but most frequently it is found in the occiput. It appears as a round, localized mass and is often distinguished from a sebaceous cyst with difficulty. It causes no symptoms except discomfort and rarely becomes infected.

The differential diagnosis between sebaceous cyst and lipoma has been discussed on page 229. The most important diagnostic point is the more or less irregular outline of the tumor mass as compared with the smooth hard sebaceous cyst. The skin is rough rather than smooth over the dome of the mass because it is pulled into depressions by the fibrous tissue septa which extend from the galea to the undersurface of the skin (Fig. 141).

Treatment. The treatment of lipoma and fibrolipoma is excision, which is usually performed for cosmetic reasons The method of operation is identical with that described for sebaceous cyst. An elliptical piece of skin should be excised over the lipoma, the incision being made over its most prominent part. In the enucleation of a lipoma, as well as of a cyst, tissue tension is applied by forceps. When the lipoma is exposed, the characteristic large fat lobules will become apparent. The dissection in a lipoma is somewhat more difficult than in a sebaceous cyst, because the lipoma is traversed by numerous fibrous tissue strands, which have to be divided in order to roll out the tumor. In our experience, it has been found easier to dissect along one side of the lipoma until the lower surface is exposed. The tumor may thus be rolled out, dissection being made as it were from below until the mass is free.

With local anesthesia containing epinephrine, no bleeding point of any consequence is encountered, and no ligatures are necessary. The wound is



FIG. 142 Carcinoma of the scalp before and after surgical excision and primary suture. This patient has had no recurrence in more than 3 years.

closed with mattress sutures and a Whitehead's varnish dressing is applied In larger incisions, a pressure dressing is used. Stitches are of silk, cotton or alloy steel wire, and they are allowed to remain in the wound for almost a week.

HEMANGIOMAS

Hemangiomas of the scalp are encountered occasionally. The diagnosis is apparent on inspection and is confirmed by noting the disappearance of the tumor mass upon compression and its reappearance upon removal of pressure. As a rule, it involves the skin and is a definite purplish red in color. It can hardly be confused with any other lesion. Treatment may be by roentgen irradiation or by injection (pp. 191-197).

CARCINOMA

The hairy part of the scalp is a rare site for carcinoma, and, when it does occur, it often appears as a degeneration of a sebaceous cyst. Most often it begins as a hardening of a portion of a cyst which has been present for a long time. Definite changes develop so that the overlying tissue becomes hard and more or less fixed, a wrinkling of the otherwise smooth scalp often being produced. Ulceration later appears and, when it does, it has the usual characteristics of carcinoma with heaped-up edges and scabbing with easy bleeding. These carcinomas are of low grade malignancy as a rule, and can be treated either by excision, which in early cases gives good results, or by roentgen radiation. Metastasis and recurrrence are late. When wide excision is necessary, it is frequently advisable to make a relaxing incision on either side of the original wound, elevating the scalp on each side.[2] Steel wire sutures in the closing of such wounds are a great advantage, since they can be left in the wound for a

long period of time without danger of reaction.

In the nonhairy scalp of bald heads, carcinoma may occur secondary to a senile keratosis. Excision, irradiation and electrocoagulation all give good results. Of these, excision gives the most rapid healing if the scalp is loose enough to permit primary suture of the wound (Fig. 142).

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. 14 .

Face, Nose, Ear, Eye

ANATOMY

The skin of the face is firmly attached to the underlying muscles by fibers of the subcutaneous connective tissue. In this network of fibers are found the vessels which supply the face with a rich circulation. The most important of these is the facial artery, which passes upward over the ramus of the jaw toward the nasolabial angle, giving branches to the upper and the lower lips. It terminates as the angular artery, which passes upward along the angle of the nose to anastomose with the infra-orbital branch of the internal maxillary artery and then with the nasal branch of the ophthalmic artery. Besides these rich anastomoses with branches of the internal carotid artery, the facial artery makes numerous anastomoses with its fellow of the opposite side (Fig. 131).

The facial vessels are easily palpable as they cross the mandible, covered only by the skin, the platysma and the areolar tissues. They may be compressed digitally to control bleeding in operations on the lower face and the lips.

The face has a rich venous network, which is somewhat unique in that the veins have no valves. They anastomose freely with those of the opposite side of the face and with branches of the internal maxillary and ophthalmic veins. The lack of valves permits an easy reversal of flow if the veins are compressed by swelling, edema or inflammation, or if they are blocked by thrombophlebitis. The practical significance of this anatomic fact is to be found in the dangerous extension of infection along the angular and the ophthalmic veins to the cavernous sinus.

The lymphatics of the face drain eventually into the deep cervical glands, but there are several individual groups of nodes which are important as first lines of defense. From the forehead, the anterior scalp and the upper lid, the lymph radicles lead first to the preauricular node. This node lies just anterior to the ear in the subcutaneous tissues, and its enlargement is often mistaken for a sebaceous or a dermoid cyst.

The areas of nose, cheek and upper lip drain first into the submaxillary nodes and from the lower lip and the chin into the submental nodes.

The sensory root of the fifth nerve transmits the sensory fibers from the face. The chief trunks are the supra-orbital, the infra-orbital and the mental. The supra-orbital enters the skull at the foramen of the same name to join the ophthalmic, or first, division of the nerve. It carries sensory fibers from the forehead and the anterior scalp. In operations upon this area (Fig. 143) under local anesthesia, it is important to block the area from below in order to block this sensory branch.

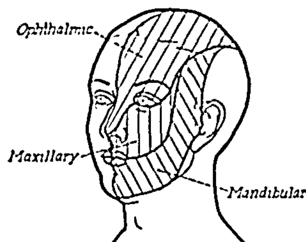


Fig. 143. Showing the sensory areas of the face and the head innervated by the 3 main divisions of the trigeminal nerve.

The infra-orbital nerve enters the superior maxilla at the infra-orbital foramen to join the second, or maxillary, branch of the fifth nerve. It supplies the lower lid, the nose, the cheek and the upper lip. In operating under local anesthesia on this portion (Fig. 143) of the face, the nerve distribution should be borne in mind.

The sensory branches of the third (mandibular) division of the fifth nerve supply the skin of the side of the head, the ear, the lower portions of the face, the chin and the lower lip (Fig. 143). The mental branch is the terminal branch which passes through the mental foramen in the mandible to supply the chin and the lower lip This nerve is easily blocked for operations under local anesthesia.

THE FACE

Injuries

Abrasions

As a rule, abrasions of the face heal kindly with a minimum of treatment. However, they must be treated carefully. Should foreign bodies such as cinders, dirt and so forth become embedded in the abrasion, the result may be disfigurement, which can be removed only with difficulty. For most abrasions, a simple thorough cleansing with soap and water is all that is necessary If the serum which escapes is allowed to dry, the firm scab which forms will be found to be the most satisfactory and the least conspicuous dressing. When foreign particles become embedded in the abrasion, an anesthetic, either local or general, may be necessary. The area must be scrubbed carefully with a gauze sponge or a small brush to remove all particles completely. A fine forceps and a sharp-pointed cataract knife may be necessary to remove deeply implanted foreign bodies. The extra time and effort given the original treatment will be well spent if a permanent discoloration of the skin of the face can be avoided. If a good soap-and-water mechanical cleansing is given, antiseptics are rarely necessary in the treatment of abrasions, but, if one is to be used, the nonstaining merthiolate solution will be inconspicuous. Dressings usually are not necessary.

Contusions

Bruises of the face are usually associated with considerable swelling due

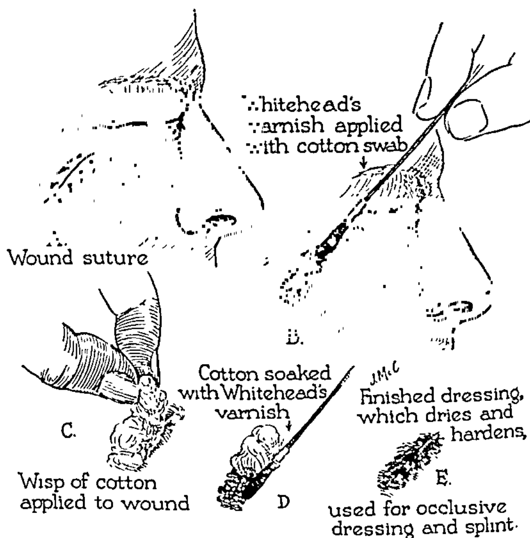


FIG. 141 Whitehead's varnish dressing for wounds of the face.

to hemorrhage and lymphatic block. The swelling is especially marked in the loose tissues round the eye, the forehead and the lip. They are best treated by cold applications during the first 24 hours and later by applications of moist heat.

Secondary ecchymoses in dependent areas are common. The area of the eye is most frequently involved, often with marked swelling of the lids. The appearance of a late subconjunctival ecchymosis should arouse suspicion of an underlying fracture of the skull.

Lacerations

Because of the very rich blood supply, the tissues of the face are relatively resistant to infection. Wounds tend to bleed freely and to heal kindly. There are two important therapeutic indications in the care of facial lacerations – the prevention of infection and disfiguring scars.

Mechanical Cleansing. Infection can usually be avoided by a thorough mechanical cleansing of the surrounding skin and then of the wound itself.

While the laceration is protected with sterile gauze, the skin round it is scrubbed thoroughly with soap and water. This may be followed, if desired, by alcohol, 70 per cent. Most facial wounds, even in children, may be anesthetized by the injection of procaine, 0.5 per cent solution, into the wound edges with a fine hypodermic needle. This may be done before the wound itself is cleaned and is perfectly safe unless the wound is grossly contaminated. The most effective method of cleansing the wound is by irrigating with sterile saline or water. The syringe used for the local infiltration will serve for the irrigation of small lesions. Relative hemostasis during this process may be obtained by pressure on the wound edges. Débridement even of contused tissue is usually not necessary in facial lacerations, and flaps of all sizes and shapes should be cleaned and saved with a fair prospect of their living.

Sutures and Dressings. Whether the wound should be sutured accurately or loosely depends largely upon its condition. In clean-cut lacerations made with glass or other sharp materials, the wounds should be closed carefully with fine suture material, horsehair, fine cotton or silk, or fine steel-alloy wire. Interrupted sutures should be used in the skin. If any deep structures are cut, these should first be brought together with interrupted sutures of fine silk. This will prevent skin tension, which often leads to wide scars. Care should be taken to obtain accurate approximation of the wound edges if a deforming scar is to be avoided. The occasional use of a vertical mattress suture will prevent the inversion of the skin edge. Unless there are definite spurting vessels, the wound suture can usually be depended upon to control bleeding. If severed ends of vessels can be seen, they should be caught with small hemostats and ligated with fine silk before suturing is attempted.

Small clean wounds of the face need no dressing. Occasionally, however, a Whitehead's varnish cocoon may be applied over the wound and the sutures (Fig. 141) to act as a protection and a splint. In clean wounds, the sutures should be removed at least in part on the second or the third day. If mattress sutures have been used, these are always removed early, some of the interrupted sutures being left a few days longer.

Blair, Brown and Byars[3,4] recommend immediate suture, especially for all wounds of double-surfaced tissues, such as the eyelid and the lip, and for all cuts or tears of the skin of the nose. If these are not sutured, distorted tissues make secondary suture difficult.

When the laceration is badly contaminated with dirt or grease and when the wound edges are badly contused, the wound should be sutured loosely with fine alloy-steel wire after the edges are trimmed. If a drain is to be used because of the fear of serum collection, a small rubber band will suffice. A light pressure dressing should be applied and left untouched for 3 or 4 days, unless pain and swelling indicate the presence of infection. If infection occurs, intermittent hot boric acid compresses should be applied. Prophylactic penicillin injections usually are given.

Penetrating wounds of the cheek and the lips are not uncommon. In children they usually involve the lower lip. The decision as to the best method of procedure depends to a large extent upon the wound. If the edges are smooth and can be approx-



FIG. 115. A periosteal elevator inserted through a small incision to replace a depressed fracture of the zygoma.

imated with narrow adhesive, no further treatment is necessary. If the wound is large and irregular, it may be sutured on the skin surface and even loosely sutured on the buccal surface without fear of infection. Salivary fistulas almost never result.

Powder Burns and Stains

Powder burns of the face are best treated immediately by painstaking excision of every powder particle. If the stains are seen late, excision of the particles and the scar with immediate suture of the tiny wounds will usually give a good result.

Burns

Burns of the face are commonly caused by explosions, scalding liquids or steam. They are usually of only first or second degree and, if they are the only burns present, the patients may be ambulatory throughout their period of treatment. If they are of first or second degree, they will heal and pain will disappear in approximately the same time whether or not local treatment is given. The local treatment may be any ointment: plain petrolatum is as good as any.

If the burn is extensive and weeping, a spray of 2.5 per cent tannic acid or an application of tannic acid solution followed by 5 per cent silver nitrate solution will give a firm coagulum which will gradually peel off as healing occurs underneath it. In caring for the local lesion, the comfort of the patient must not be forgotten.

Sedatives should be given in sufficient quantities to give him relief during the first 24 to 48 hours.

Fractures of the Malar Bone and the Zygoma

These fractures are usually caused by blows or other injuries to the side of the face. The possibility of such a fracture must be borne in mind in injuries of this area. When there is no displacement, a positive diagnosis can be made only by roentgen examination.

Symptoms. When the malar bone and the zygomatic arch are depressed, there is a typical facial deformity which is characterized by a flatness of the side of the face and a lack of expression. As a rule, there is little crepitation, and, because of the accompanying swelling, the fracture is frequently overlooked. Within 24 to 48 hours, a definite discoloration of the eyelid and gradually advancing subconjunctival ecchymosis appear. Eating may be painful, and, if hemorrhage has extended into the orbit in considerable amount, there may be double vision for a time due to a secondary edema and partial loss of function of the extra-occular muscles

Roentgen examination is necessary to rule out fracture in cases of marked swelling, and it is of value even in those cases in which the diagnosis has been made.

Treatment. In the case of a fracture without displacement, no treatment is required. There is no tendency toward displacement of the fragments, and the accompanying contusion will usually subside under local applications of heat without any complications.

Fractures of the malar bone or the zygomatic arch with displacement are best treated early if facial deformity is to be avoided. Ivy and Curtis[10] recommend immediate elevation of the depressed fragments. They obtain an actual purchase on the depressed fragment by the use of a screw-porte, an instrument something like an awl, with a screw-thread point. This is introduced into the depressed bone through a small incision, and, once it grips the bone firmly, the fragment may be pulled into position, the instrument being used to produce traction. An ordinary gimlet may serve in lieu of a screw-porte. There is little tendency toward recurrence of the deformity, and no dressing is necessary.

Depressed fractures of the zygomatic arch can usually be palpated easily and brought into position by other methods. They may be levered into position by the introduction of a periosteal elevator through an incision within the hairline.[8] This operation may be performed under local anesthesia. A small incision is made just above and in front of the ear and carried downward through the temporal fascia. The periosteal elevator is then introduced through the opening in the temporal fascia and carried downward to the undersurface of the zygomatic arch (Fig 145). By leverage, the depressed bone may be brought into position and the small wound is sutured after the periosteal elevator has been withdrawn.

Elevation of depressed fractures of the zygoma may also be accomplished by leverage with a periosteal elevator placed within the mouth between the cheek and the molar teeth. By pressure upward in this area, the tip of the elevator may be placed beneath the depressed fragment, and, by manipulation, the deformity may be reduced.

When the depressed fracture is lim-

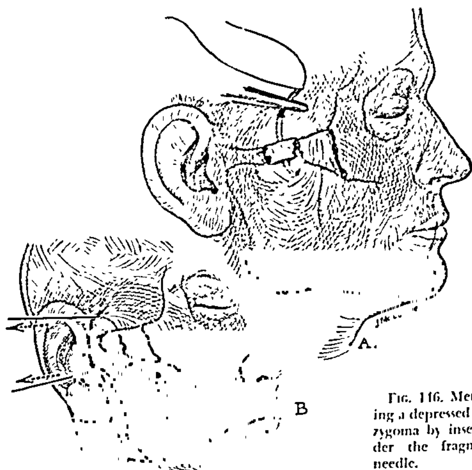


Fig. 146. Method of elevating a depressed fracture of the zygoma by inserting wire under the fragments with a needle.

ited to the zygomatic arch, Ivy and Curtis[10] recommend reduction of the deformity by the method of Matas.[13] The depressed fragment is pulled up into place by means of a wire introduced beneath it. With a heavy curved needle, heavy stainless steel wire is placed beneath the arch and the needle is introduced through the skin above the bone and withdrawn below (Fig. 146A) after it has passed underneath the arch. By pulling on the loop of wire, the depressed fragments may be brought up into position (Fig. 146B) If there is any tendency toward recurrence of the deformity, more than one wire may be introduced and tied over a glass slide or a piece of tongue depressor, which rests on the firm bone in front and back. The wires should be removed in 6 or 7 days.

Plastic Surgery

Scars

Unsightly facial scars are becoming more common because of the increasing number of automobile accidents. The destruction of tissue and the inadequate suture of such wounds often lead to disfigurement and secondary psychic trauma which may greatly outweigh the physical injury. In a great many such cases, the cosmetic result may be greatly improved by well-planned plastic procedures.

Treatment. Many of these procedures may be performed on ambulatory



Fig. 147. (*Left*) Old traumatic scar of face and eyelid. (*Right*) Three months after excision of the scar and resuture of the wound under local anesthesia.

patients, usually under local anesthesia (Fig. 147). The scar is excised and the skin is undermined for a distance on either side of the wound. Skin tension is relieved by inserting a sufficient number of buried interrupted sutures of fine silk, and the skin is approximated carefully with a subcuticular suture or with interrupted sutures of horsehair or fine silk. Wound dressings and splinting with a Whitehead's varnish cocoon do away with cumbersome bandages and adhesive (Fig. 144).

If loss of tissue necessitates skin graft after excision of the scar, the thick split grafts described by Blair and Brown[2] can easily be cut and sutured in place over small defects. This type of work must be planned well before it is attempted, and it must not be done in a hurry or without adequate equipment. The face and the forehead, however, can be immobilized as well in an ambulatory as in a hospital patient; hence, minor types of plastic surgery of the face may be performed with excellent results in patients who are at home during their period of treatment.

Skin Tumors

Treatment. Various other types of plastic surgery of the face can be performed in ambulatory patients. Facial tumors, such as moles and skin papillomas, can easily be removed under local anesthesia.

In treating the smaller lesions, there is a choice between elliptical excision of the lesion, with primary closure of the wound with fine sutures, and elec-

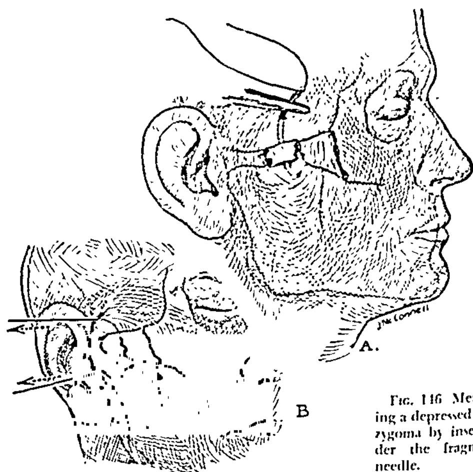


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Fig. 150 (*Left*). Carbuncle of the upper lip.
Fig. 151 (*Right*). Furuncle of nasal septum.

fine silk or wire may be used to close the skin wound.

Harelip

Another type of plastic surgery that is sometimes performed on the ambulatory patient is the repair of harelip of minor type. As a rule, attempted repair of this defect in babies and children is a hospital procedure, but in a few adults with incomplete unilateral harelip or conspicuous scars from previous attempts at repair, plastic repair of the lip may be performed under local anesthesia in ambulatory patients with very successful results. Fig. 149 illustrates one such simple method of repair.

Infections

Furuncles

Anatomy and Pathology. Furuncles of the face are staphylococcal infections which differ little pathologically from furuncles elsewhere on the body. Their peculiarity lies in the anatomic and the physiologic characteristics of the skin of the face. The muscles of facial expression insert directly into the skin of the face, so that talking, eating, drinking, even thought and emotion, result in facial movement. Thus, in facial lesions it is difficult to obtain the limitation of motion which favors the localization of infection. Another factor which definitely favors the spread of the infection is the almost uncontrollable tendency on the part of both patient and doctor to squeeze a facial furuncle. This factor, which Maes[12] believes is active in at least 90 per cent of all serious cases, breaks down the barrier of inflammatory induration and permits a spreading of the cellulitis by contiguity.

The so-called *dangerous area* of the face consists of the upper lip (Fig. 150) and the nose (Fig. 151) and, to lesser extent, the forehead. Furuncles in these areas are potentially dangerous because the skin over them is almost constantly in motion, which hinders localization, and because extension of the infection may involve the numer-



Fig. 148 (*Left*) Large disfiguring pigmented mole of the face. (*Right*) Same patient one year after excision of the mole. The linear scar, extending from the outer corner of the eye downward, is barely visible.

trocoagulation of the skin blemish. The end results are about equally good. Electrocoagulation has the advantage of requiring no dressing; on the other hand, the dressing following the excision need not be unsightly, nor need it be worn for a long period.

The larger blemishes are best treated by excision (Fig. 148). In suturing wounds after removal of a large defect, it is important to free the skin for a considerable distance round the lesion in order to close the wound without tension. It is well to use a few buried interrupted sutures of silk in the subcutaneous tissues to relieve the tension in the skin. Horsehair,

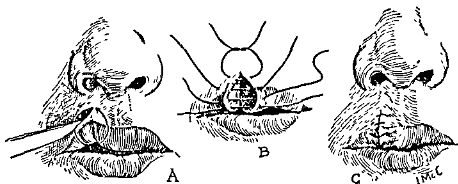


Fig. 149. Minor harelip deformity which may be treated under local anesthesia in an ambulatory patient.





FIG. 150 (*Left*). Carbuncle of the upper lip.
FIG. 151 (*Right*). Furuncle of nasal septum

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ous venous branches, which results in a progressive thrombophlebitis. The blocking of the veins by the infection may permit venous drainage along the angular and the ophthalmic veins into the cavernous sinus. Once a thrombosis of the cavernous sinus occurs, the infection becomes much more serious. This potential danger, resulting from a relatively innocent furuncle, must be borne constantly in mind, and a frank and simple warning to the patient will do much toward obtaining his co-operation in carrying out the rigid details of the necessary treatment.

Carbuncles of the Lips

Carbuncles of the face are seen most commonly on the lips (Fig. 152). The infection is characterized by a large area of local swelling and extensive surrounding cellulitis. As the lesion progresses, pus drains from numerous small openings.

Treatment. The antibiotics have supplanted all other forms of therapy for furuncles and carbuncles of the face and the lips. This therapy is best carried out after culture and sensitivity tests have been made of the invading organisms, but until the results of these tests are available, the long-acting penicillin, given intramuscularly in doses of 300,000 units, is usually helpful.

Cellulitis

Cellulitis of the face occurs occasionally as a result of infection following an abrasion. The characteristic redness and edematous swelling of cellulitis elsewhere in the body are noted in the face, and the edema is particularly marked in the loose tissues about the eye. Because such infection is most often caused by streptococci, a systemic reaction may also be present. Treatment consists of rest of the part, which usually means bed rest, and the application of hot moist compresses. Because the cellulitis is due most often to streptococci, the use of penicillin is almost routine now.

Erysipelas

Etiology and Symptoms. The face is one of the most common sites of erysipelas, which apparently arises spontaneously through an infection in a minute opening in the skin. It is seen most frequently in older people during the spring and the fall months. There is a definite tendency to recurrence. Most often the lesion appears first on the nose, then extends on either side over the cheeks and the forehead in a butterflylike configuration The appearance of the infection is typical—raised red edges and a tendency to branch from the central part of the lesion. The cellulitis involving the eyelids is associated with considerable edema and swelling. In the early and moderate cases, there is only a very slight systemic reaction, and such patients may easily be kept ambulatory.

Treatment. This infection responds rapidly to penicillin therapy.

Cysts

Blackheads

Etiology. Blackhead is the common name given to the retention of sebaceous material in the outlet of sebaceous ducts. The duct opening is dilated and the sebaceous material is marked by a black spot of collected dust. In some cases, the blackhead may be very large, and a sebaceous cyst may form below it. In other cases—as,

Fig. 152 Carbuncle of the lip with associated cellulitis of the face. Note the edema of face and eyelids. This patient treated himself for several days and, after squeezing the carbuncle, developed a lateral sinus thrombosis and a positive *Staphylococcus aureus* blood-stream infection.







Fig. 153. (*Left*) Large boil of upper lip with facial cellulitis and edema and abscess along the right nasolabial fold (*Right*) Same patient 5 days later after incision of abscess and intensive penicillin therapy. It seems likely that a cavernous sinus thrombosis was aborted by penicillin in this case.

for instance, on the nose (Fig. 154), the neck and the ear—the blackheads may be small dots which are disfiguring because of their presence in these prominent places They are most often seen in younger individuals and especially in those in whom the sebaceous secretion is excessive. The association of blackheads and acne is common.

Treatment. Blackheads are easily treated by the simple evacuation of the sebaceous material by pressure. This is best applied with a small metal spoon in which a round perforation is cut. The perforation is placed over the area of sebaceous retention and pressure is exerted; the blackened external portion of the retained sebaceous secretion and a wormlike whitish portion of the underlying material may be evacuated. The frequent use of soap and warm water to keep the areas clean and repeated evacuations of the sebaceous material will permit the ducts to regain their normal size and the blackheads will disappear.



Fig. 154. Blackheads of the nose.

Sebaceous Cysts

The ordinary sebaceous cyst may occur anywhere, but it is seen most commonly on the cheek. These cysts occur frequently as small hard nodules, and they persist over a period of years. They often enlarge rapidly because of infection and become red and painful.

Treatment. The treatment is the same as for the same lesion elsewhere on the body (p. 181). In cysts which are not infected, excision may be performed. When possible, the incision should be made to correspond with the normal creases or wrinkles in the skin and thus keep the scar to a minimum. When these cysts become infected, only incision may be possible, though often at the time of incision it is possible to remove the cyst lining or to cauterize it with pure phenol. In cases of infected cysts, it may be well to suture the wound partially and obtain the needed drainage with a piece of rubber dam in one corner of the wound. In this way, a prominent scar is avoided, and the infection usually subsides at once after incision and drainage. These operations can be performed under local infiltration anesthesia.

Pili Incarnati

This cyst, which is also termed an implantation cyst, occurs not infrequently in men due to an ingrowing. hair of the beard. The hair grows underneath the superficial layers of the skin, curls up and forms a hard mass. Such cysts have no true capsule. They may be treated either by com-



Fig. 155. Dermoid cyst of the eyebrow.

plete excision of the area under local anesthesia or by incision and turning out the curled-up hair, in which case the cyst will disappear spontaneously

Dermoid Cysts

Etiology and Diagnosis. Dermoid cysts arise from an infolding of the ectodermal tissue along one of the lines of embryonic closure of the skin. In the face they occur at the outer angle of the eyebrow (Fig. 155) and round the lobe of the ear. They may appear at any age, but they are seen more commonly in childhood and youth than in maturity. The walls are made up of stratified epithelial elements containing hair follicles, and the contents consist of sebaceous material, so that, by palpation or even on histologic examination, they are often mistaken for sebaceous cysts. They differ from sebaceous cysts in that they invariably have a deep attachment to the fascia or the periosteum, which in some instances makes their dissection and removal somewhat difficult. Occasionally, they are also

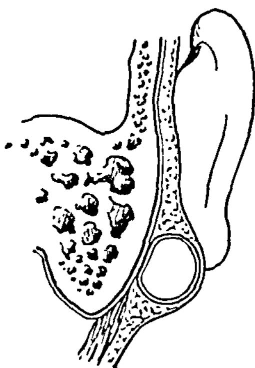


Fig. 156 Dermoid cyst behind the lobe of the ear The deep attachment of the cyst to the underlying periosteum is shown diagrammatically This often makes the removal somewhat more difficult than is usual with a simple sebaceous cyst.

attached to the skin, but this attachment usually is over a wide area and not at a single point, as is the case with sebaceous cysts. The appearance of dermoid cysts at an early age and their definite deep attachment are the most important diagnostic points. It is important to make a differential diagnosis because, not infrequently, the excision of a dermoid cyst is attended with considerable difficulty due to its deep attachment (Fig. 156). This necessitates much more in the way of anesthesia, retraction and surgical manipulation than is the case with a simple sebaceous cyst.

Treatment. The treatment of a dermoid cyst is excision because of the

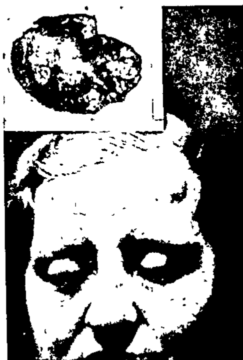




FIG. 157 (*Left*). Fibrolipoma of the forehead. Inset shows the tumor after its removal.

FIG. 158 (*Right*). Papilloma of the lip.

disfigurement which it causes and because of the fact that it may become infected. This may be performed under local infiltration and field-block anesthesia. In cysts of the eyebrow, the hair should be clipped rather than shaved. After the injection of procaine, the superficial portion of the cyst may be freed without difficulty. Usually, however, the deeper attachments must be freed by sharp dissection, often down to the periosteum and along the line of the orbit. After removal of the cyst, the wound should be closed with buried fine silk sutures, with silk or fine steel wire sutures in the skin. A pressure dressing should be applied for 24 hours, and the patient should be warned that edema and swelling of the eyelid are to be expected for from 24 to 48 hours. Usually, the pressure dressing is removed after 24 hours. No further dressing is necessary, but a cocoon of Whitehead's varnish may be applied. Because of the location of the cyst in the hairline of the eyebrow or behind the ear, practically no visible scarring remains.

Infected Preauricular Nodes

Etiology. In speaking of cysts of the face, it may be well to mention a lesion which is frequently mistaken for a cyst, namely, an infection of the preauricular node. This node lies in front of the ear, in the subcutaneous areolar tissues, and is frequently enlarged secondary to infections of the forehead, the anterior portion of the scalp and the teeth. By the time the patient is seen, the primary infection

may have disappeared and the large node remain as a swelling in front of the ear.

Diagnosis. It is comparatively easy to make the differential diagnosis between a cyst and an infected node if one is aware of the presence of this node. The history of the previous infection and of the subsequent development of swelling in front of the ear is helpful. The lack of mobility of the node in the surrounding tissues and of the skin over the swelling differentiates it from a sebaceous cyst.

Treatment. If the node is fluctuant, incision and drainage under local anesthesia are performed; usually a small piece of rubber dam is all that is necessary as a drain. If the node is not fluctuant, applications of moist heat may produce a rapid subsidence of the swelling or hasten the progress of fluctuation so that incision and drainage may be performed. Roentgen irradiation may be worth while in the treatment of nonsuppurative nodes.

Benign Tumors

Fibrolipomas

Diagnosis. A common benign tumor of the face is a fibrolipoma (Fig. 157). This appears most often on the forehead, and it is frequently mistaken for a sebaceous cyst because of its hardness on palpation and its definite circumscribed body. It is differentiated from a sebaceous cyst, however, by the fact that it has no attachment to the skin, that it has an irregular rather than a smooth surface, and that it seems to be fairly well fixed in the subcutaneous tissue.

Treatment. These tumors may easily be excised under local anesthesia. In placing the incision, it is well to bear in mind the natural creases of the skin of the forehead and, if possible, to place the incision in one of these creases.

After incision through the skin and the subcutaneous tissue, the tumor is encountered and usually is found to be lying in a well-developed capsule from which it can be shelled out by sharp dissection. In closing the wound, it usually is advisable to place several deep sutures in the subcutaneous tissue before closing the skin so as to control whatever bleeding points may be present. Skin closure is best performed with fine sutures of horsehair, fine silk or alloy steel wire. A cocoon dressing of Whitehead's varnish (Fig. 144) forms a good splint. If there is any question of the formation of a dead space where serum might collect, a pressure dressing with a circular bandage round the head will be of value for 24 hours. Sutures should be removed in 3 or 4 days and the wound should be splinted once more by the application of another Whitehead's varnish cocoon.

Cutaneous Papillomas, Warts, Moles

Treatment. Patients frequently seek the removal of skin blemishes for cosmetic reasons (Fig. 158). The treatment of these lesions depends somewhat on their size and their location. Ordinary papillomatous lesions of small size are best treated by electrodesiccation, which may be carried out under local anesthesia. The lesion is removed by the desiccating needle and no dressings are necessary. The eschar usually falls off in 6 or 7 days, leaving a small mark which rapidly disappears. Care should be taken not to desiccate too deeply, otherwise a depressed scar may result.

Equally good results may be obtained by surgical excision of these

Fig. 159 Hemangioma of the upper lip treated by application of radon seeds. (Brown, J. Barrett, and Byars, L. T.: Am J. Surg. 39:452-457)



Fig. 160. Basal-cell carcinoma of the face.

lesions. Under procaine-epinephrine infiltration anesthesia, introduced beneath and round the papilloma, a wedge-shaped ellipse of tissue containing the lesion is excised. The wound should be closed with several fine interrupted horsehair or silk sutures. In suturing such wounds, the most satisfactory approximation results if, first, a vertical mattress suture is placed in the center of the wound and then one simple suture is inserted on each side. The sutures provide hemostasis. No dressing is required unless there is some ooze, in which case a small pressure dressing may be applied with narrow adhesive for 24 hours. If a protective dressing is desired, a Whitehead's varnish cocoon is excellent. The sutures are removed on the third or the fourth day.

Hemangiomas

Port-Wine Hemangiomas. Hemangioma of the face is a not uncommon form of benign tumor. There are several different types. The so-called *simple hemangioma* is a flat smooth tumor composed of numerous dilated capillaries and venules lying directly beneath the epidermis, so that the color of the blood imparts the typical port-wine color to the nevus. This tumor is best treated by the radiologist or the dermatologist.

Plexiform Hemangiomas. The second type is a slightly raised reddish blue tumor of the skin and the subcutaneous tissues. This is the plexiform hemangioma, and it is composed of dilated capillaries and venules with very little perivascular connective tissue. It tends to remain localized and usually does not infiltrate or destroy tissues.

This hemangioma may be treated in several ways.[11] Surface irradiation may be used. Repeated applications of carbon dioxide snow sometimes produce sclerosis and a disappearance of the tumor. Injection into the mass of one of the sclerosing solutions used for varicose veins may be effective in closing the vessels and producing a shrinkage of the tumor. (See p 193.)

Cavernous Hemangiomas. The third group of hemangiomas is the cavernous type. These are spongy purplish-red tumors which protrude above the skin and often extend deeply into the underlying tissues. They are composed of hypertrophied abnormal vessels, mostly arterial in type, and tend to grow and infiltrate surrounding tissues.[10]

Treatment is usually sought in infancy for these growths. They may be treated by surgical excision, but when they are on the face, excision is not always desirable because of the defect which may remain.

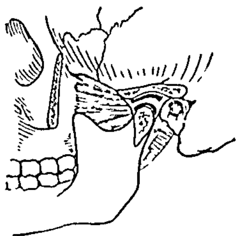
Brown and Byars[5] recommend surface irradiation in those lesions in which the involvement is not deep. When excision or surface radiation is not applicable, they have obtained excellent results by the implantation of gold seeds containing from 0.25 to 0.5 millicurie of radon (Fig. 159)

BASAL-CELL EPITHELIOMAS
(RODENT ULCERS)

Etiology and Course. The most common malignant tumor of the face and the only one which can be treated while keeping the patient ambulatory is the basal-cell epithelioma or rodent ulcer (Fig 160). This lesion arises from the basal cells of the skin and appears most often on the sides of the face or on the forehead. It early forms an ulceration which is characterized by a deep crater with heaped-up edges, usually covered with a crust of dried serum.

These lesions usually appear in individuals past midlife. They grow slowly and do not tend to metastasize. If they are treated radically and early, a cure can be accomplished in almost every case. The requisite of the first treatment is that the lesion be completely destroyed or removed; otherwise it will recur, when growth always is more rapid and, therefore, more dangerous.

Treatment. There are three methods of therapy which may be used in these cases, roentgen or radium irradiation, destruction by electrocoagulation, and surgical excision. It makes little difference which method of treatment is used if the entire lesion is removed. The choice of treatment



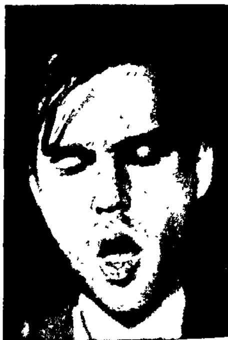


FIG. 161 (*Left*). Section of the temporomandibular joint showing size and position of the articular cartilage and the insertion of the external pterygoid muscle into the capsule of the joint and the neck of the condyle of the mandible.

FIG. 162 (*Right*). Patient with dislocation of the jaw showing forward position of the mandible.

depends somewhat upon the situation and the extent of the lesion. If it is found to be overlying soft tissue and if the skin is sufficiently loose to permit primary closure of the wound, excision under local anesthesia with primary suture of the wound perhaps offers the most rapid cure. In surgical removal of such tumors, the incision must be made wide of the lesion and should include a wedge-shaped excision of the underlying fatty tissues.

Electrocoagulation of rodent ulcers is also a safe and a rapid method of destroying the tumor. The ulcer and the tissue for a distance round it should be destroyed by the coagulating needle. This leaves an eschar, which eventually separates by necrosis. Healing will take place by granulation and epithelization, or it may be hastened by skin graft.

Irradiation also offers a high percentage of cures in rodent ulcer. The advantage of this treatment is that less tissue is destroyed by this method than by electrocoagulation. It is preferable for the treatment of large neglected ulcers in which primary suture of the wound cannot be accomplished.

SURGICAL LESIONS OF THE TEMPOROMANDIBULAR JOINTS

Anatomy

The temporomandibular joint is relatively small but unique in many ways. It is in almost constant use through eating, talking and other motions of the jaw. It is frequently traumatized, yet it develops few pathologic lesions requiring surgical interference. The joint is a complicated one, containing an intra-articular fibrocartilage which divides the joint cavity into an upper and a lower compartment. This formation of the joint permits two main movements: (1) a hinged movement between a condyle of the mandible and the fibrocarti-

lage; and (2) a gliding motion which permits an anterioposterior motion of the jaw. This movement is almost entirely due to the riding forward of the condyle and the intra-articular cartilage on the eminentia articularis of the temporal bone. The "cartilage" is composed mostly of fibrous tissue, but it also contains some cartilaginous cells. Its undersurface is concave to conform to the roundness of the condyle of the mandible. The external pterygoid muscle, which arises from the side of the skull, passes backward and inserts on the capsule of the joint and the neck of the condyle. It is important because, in cases of dislocation, the intra-articular disk follows and is dislocated with the mandible, due to contracture and pull of the muscle (Fig. 161).

Dislocations of the Mandible

Etiology. Dislocations of the mandible occur most frequently in males, and almost invariably they are the result of a blow on the tip of the jaw when the mouth was open. When the mouth is open, the condyles of the mandible are held forward almost at the edges of the articular eminences, and a blow on the tip of the jaw, because of the tenseness of the pterygoid muscles, permits a rotationlike action in which the condyles slip forward anterior to the articular eminence. Secondary contraction of the external pterygoids pulls the condyles of the jaw forward, and contraction of the masseter and the temporal muscles pulls the jaw upward and holds the condyles in this forward position (Fig. 162). Dislocation is almost invariably bilateral. Wakeley[18] cites the most common causes of dislocated jaw in 38 cases: 20 occurred in boxing bouts, 9 during dental extractions of the posterior lower third molar teeth; and only 1 from spontaneous laughing or yawning.

Diagnosis. When dislocation has occurred, the patient shows a characteristic deformity: the lower jaw is relatively prominent and forward upon the upper jaw, and the mouth cannot be closed. It may be possible to palpate a slight depression in front of the ear at the site of the usual location of the mandibular condyle.

Treatment. Usually, reduction of the dislocated mandible is performed easily without anesthesia, and, once it is reduced, there is little tendency toward recurrence. To bring about reduction, the condyles must be depressed and pushed back to their proper location in the articulation. This may be accomplished most easily by padding the thumbs with gauze bandages and depressing the posterior part of the jaw by pressing downward upon the molars, the fingers on the outside of the jaw lifting up on the point of the chin. By pressing downward and backward until the condyles are free of the articular eminence, the dislocation can usually be reduced.

If, by reason of local hemorrhage and fibrosis, there is difficulty in reduction by this manual means, wedges of wood or cork may be inserted between the molar teeth. Using these wedges as a fulcrum and pushing upward upon the tip of the jaw, the condyles are brought downward and back of the articular eminence into their normal position. It may be well to immobilize the jaw after reduction by the application of a Barton's bandage for a week or 10 days.

Mandibular Meniscus Syndrome

Etiology. Injuries to the intra-articular disk of the temporomandibular

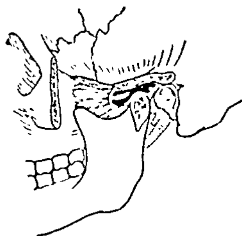


FIG. 163 Section through the temporomandibular joint showing the posterior detachment of the articular cartilage and its forward position due to the pull of the pterygoid muscle

joint may occur due to a violent cough, sneeze or yawn, especially if the pterygoids are contracted in trying to prevent the action. Injuries are occasionally due to trauma. The injuries result in a detachment of the posterior portion of the intra-articular cartilage which permits it to be drawn forward by the external pterygoid muscle (Fig 163) The cartilage lying in the joint becomes traumatized, with resultant pain, there is often a clicking sensation when the jaw is opened or when one chews, and sometimes there is a blocking of the joint from malposition of the detached cartilage. The pain in acute cases is often referred to the ear and the posterior portion of the scalp, and there may be an associated salivation.

Treatment. When the dislocation is recent and acute, it is often possible to replace the cartilage in its normal position in the joint by exerting continued pressure behind the condyle of the jaw while the mouth is open. By this method, the condyle will b pushed forward into its normal pos tion in the concave lower surface c the articular disk. As the mouth i closed, the cartilage can be replace in its normal relation to the condyl in the joint. Sometimes this occur with a definite click and the patien experiences a feeling of relief fron the obstruction.

Most often the obstruction is re current and chronic, producing snap ping sounds with each opening an closing of the jaw. This is audible no only to the patient, because of th proximity of the joint to the ear, bu also to others. In females, the psycho logical effect may be particularl marked. The symptoms in thes chronic cases are very similar to those which Schultz[17] described as being due to a chronic subluxation of the temporomandibular joint. He believes that the symptoms may at times be due to a congenital weakness of the capsule or malformation of the condyles, or both, or that the ligaments of the joint may have suffered strain or injury. Many of the symptoms are indistinguishable from those of injury to the articular cartilage.

The treatment of snapping jaw has not been too successful by conservative methods. Immobilization of the joint by bandages or wiring of the teeth is not easily borne by the patient, nor is it promising in its results. Certain of these patients may be relieved by the injection of sclerosing substances into the joint. Alcohol or quinine and urethane have been used in small amounts (0 25 cc.) More recently, Schultz[17] has reported the injection directly into the joint of sodium psylliate in doses of from 0 25 to 0.5 cc. The needle is introduced perpendicular to the skin just in front

of the ear. The joint is identified with the left index finger by the anterior movement of the condyle as the mouth is opened. Injections are given once or twice weekly until sufficient fibrosis is obtained to prevent a recurrence of the subluxation. This usually occurs in from 3 to 5 weeks (3 or 4 injections). The author has seen Schultz's[17] patients and has treated several patients of his own successfully by this technic. Sodium Morrhuate was injected in doses of 0.5 cc. There usually is some swelling and discomfort, which lasts from 2 to 4 days after injection and subsides without treatment. The operative treatment for displaced intra-articular cartilage is excision of the cartilage. This operation is not difficult, but it usually requires hospitalization of the patient for a day or two. Both Wakeley[18] and Dubecq[6] recommend the operation and report excellent results.

THE NOSE

Foreign Bodies

Children quite commonly place foreign bodies in the nose, and often considerable judgment and care are required if their removal is to be accomplished without damaging the intranasal structures or without losing them by their passing into the stomach or the lower respiratory tract. They are divided into two groups—the animate and the inanimate. Examples of the former are flies, maggots, centipedes and leeches. Such inanimate bodies as beads, stones, buttons, peas and beans are very commonly found in the nasal chambers. The symptoms they produce may simulate very closely nasal or sinus infection, and often a specialized technic or instrumentation is required for diagnosis. A roentgenogram is useful in many cases.

Removal. In removing foreign bodies from the nose, general anesthesia is often necessary because of the lack of co-operation of the child. A slender metallic probe with a small hook on the tip is the most useful instrument. Fine nasal forceps are also satisfactory. Insects can be killed promptly with a small amount of chloroform vapor. A popular method of removal among physicians is the syringing of the nose, the idea being to force the object out of the opposite nostril. This is a dangerous method and should not be used for fear of infecting the accessory sinuses or the middle ears.

Injuries to the Nose

Etiology and Diagnosis. Injuries to the nose often result from blows or falls on the face and give rise to contusions with subcutaneous hemorrhage which may extend rapidly into the loose tissues of the lower eyelid. The associated injury which must always be suspected is fracture of the nasal bones. This diagnosis may easily be made in some cases due to the displacement or the flattening of the nose or by crepitation on palpation. In other cases, the diagnosis may be difficult. A roentgen examination is advisable in all adults.

Treatment. In the treatment of nasal contusion, cold compresses are of value if applied early, but, if the lesion is not seen until late, little can be accomplished by this therapy. Warm compresses may be helpful in hastening absorption of the ecchymosis.

Fractures of the nose are best treated by a skilled otolaryngologist; they are nearly always compound, on either the skin or the mucosal surface. In

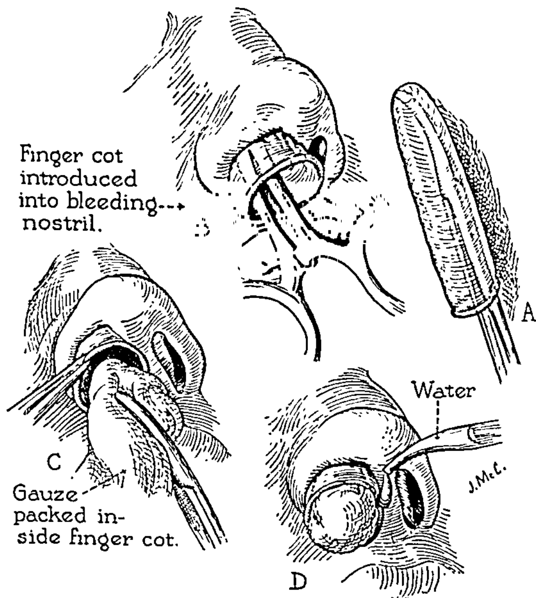


FIG. 161 Method of using a finger cot for control of bleeding from the nose.

many cases, however, adequate emergency treatment may be necessary. Two important requisites should be kept in mind—the restoration of adequate air passages and the prevention of nasal deformity. Of these two, the restoration of the air passages is more important. In very recent injuries, it is often possible to accomplish both requirements by introducing into the nose a curved hemostat or closed small curved scissors. By pressure within the nose with the instrument and molding on the outside with the fingers, it is relatively easy to replace the broken fragments in their normal position without anesthesia. As a rule, there is little tendency for the deformity to recur if the fragments and the septum have been placed in their normal position. Packing the nose after reduction of a fracture is not neces-

sary and may predispose to infection of the sinuses. Fractures of the nose should be reduced promptly because the rich blood supply to it may permit the fragments to "set" in a displaced position very early. In older injuries or in cases in which the deformity tends to recur, the patient's best interests are served by referring him to a specialist in nasal surgery.

Nose Bleed (Epistaxis)

Hemorrhage from the nose is a common occurrence and, as a rule, is mild and easily controlled. Most often it occurs from a small venous radicle along the side of the septum and, therefore, can be controlled easily by simple pressure. With the patient sitting up, pressure with a simple pledget of cotton inserted into the nostril is usually all that is necessary. If epinephrine is available, cotton or gauze may be soaked with it and inserted into the nostril at the bleeding point. In a few cases, it may be necessary to apply continuous pressure. This is best done by inserting a finger cot or the finger of a rubber glove into the nostril (Fig. 164). The end of the finger cot is held open and the cot is packed tightly with dry gauze or ribbon packing. The gauze then is moistened; this causes it to swell and produce firm and continuous pressure at the bleeding site. The pack may be left in place for from 12 to 18 hours. Uncontrollable bleeding or recurrent bleeding is best treated by the otolaryngologist.

THE EAR

Foreign Bodies

The management of foreign bodies in the ear becomes important when it is considered how frequently such accidents occur and how the integrity of hearing may depend on the skill and the judgment with which such cases are handled. Such foreign bodies are divided into two groups—the animate and the inanimate. The former includes insects of all kinds and larvae; the latter includes such material as peas, beans, hairs, pieces of matches, toothpicks or pencils, and chips of stone or metal.

Removal. In the removal of foreign bodies, certain procedures should be followed. A general anesthetic may be advisable in small children. If the object is a live insect, it should be killed promptly by instilling in the ear some nonirritating oil, such as olive oil, liquid petroleum or kerosene. Syringing the ear is the method of choice for removal, boric acid, salt or any mildly antiseptic solution being used. Persistent douching of the ear should be tried before abandoning this method. If it is not successful, some type of forceps or a small metallic hook may be tried. Metallic mercury has been used at times to float the body to the surface. A wire loop may be successful when other methods fail, of the foreign body may adhere to a brush containing glue at its tip. Occasionally, it is necessary to detach the auricle by incising through the skin and the cartilage posteriorly. This allows the cartilaginous canal to be turned out, and the object can then be picked off easily.

Injuries to the Ear

Lacerations

Lacerations of the ear, especially cuts into or through the substance of the ear, are best treated by immediate suture Sufficient skin and cartilage should be trimmed away to make good approximation possible. The cartilage is repaired by the insertion of fine

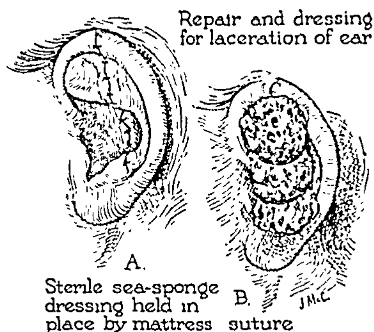


FIG. 165. Repair of laceration of the ear using a sterile sea sponge as a dressing and splint.

silk sutures. Skin closures are made loosely enough to permit serum drainage, and a pressure dressing is applied. The best dressing is formed by a damp sea sponge which conforms to the irregularities of the ear surface and, as it dries, forms an excellent splint (Fig. 165). Such dressings should be allowed to remain in place for at least 5 or 6 days, unless local pain or other evidence of infection makes redressing imperative.



FIG. 166. Hematoma of the ear.

Hematomas

Hematoma of the ear is seen commonly in boxers and wrestlers and in contusions of the ear from any cause (Fig. 166). A fluctuant swelling appears on the anterior surface of the ear which, if left alone, gradually undergoes organization and secondary fibrosis. The resulting deformity in cases of repeated hematoma is spoken of as "cauliflower ear."

The treatment of hematoma of the ear is drainage of the blood and the serum which are found between the skin and the cartilage. This is best performed within 24 to 48 hours of the appearance of the hematoma. Drainage may be accomplished by introducing a large needle through a wheal of local anesthesia, or a small incision may be made at the most dependent part of the hematoma. There is a tendency to recurrence of

the swelling unless drainage is provided. In an effort to provide free and continuous drainage and so to prevent a re-formation of the collection, Howard[7] excises a bit of skin and perichondrium with a punch or a knife. This may be advantageous in some cases, but, as a rule, sufficient drainage may be obtained through the opening made by a size 14- or 16-gauge aspirating needle.

A pressure dressing is applied by one of several methods. A moist sea sponge may be introduced into the ear over a gauze dressing padding the space between the scalp and the dorsal surface of the ear. The dressing



Fig. 168. Cotton collodion pressure dressing held in place by bent hairpin for hematoma of the ear. (Ferguson, L. Kraeer J. A. M. A. 100:736)

Fig. 167. Pressure bandage of the ear.

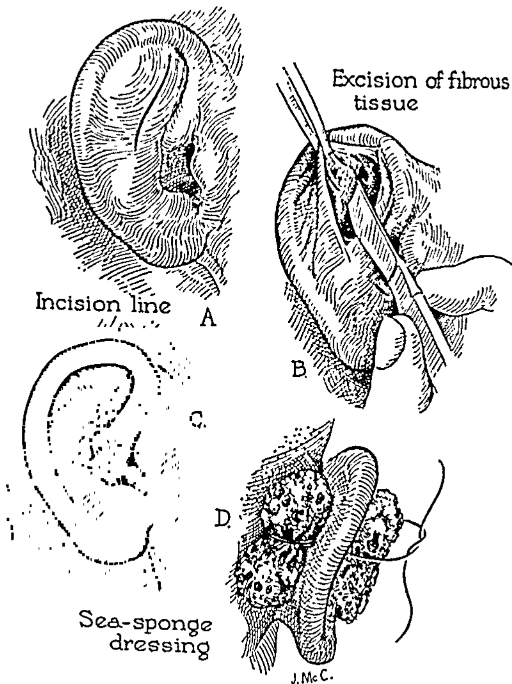


FIG 169 Plastic surgery of the ear. Excision of the fibrous tissue between the skin and the cartilage of the ear following repeated hematomas. Note use of sea sponges applied in the through-and-through sutures to produce elastic pressure after operation.

must be held in place by a circular bandage involving the head and the ear (Fig. 167). Another form of pressure dressing which has been found to be useful in the treatment of these cases is cotton soaked in collodion. This is molded to the auricle so that it fits accurately into the depressions in the ear. The cotton is also carried over the back of the ear so that, as

it dries, it forms a firm cast for the auricle. Pressure on the area of the hematoma may be maintained by so bending a hairpin as to produce light pressure on the front and the back of the ear (Fig. 168). This dressing may be left in place for 5 or 6 days, when it may be removed without danger of recurrence of the hematoma.[7]

Occasionally, a patient with an old hematoma of the ear may wish to have the deformity removed. In such cases, the fibrous tissue producing the deformity may be excised under local anesthesia. The skin is separated from the underlying scar tissue along one of the natural creases of the ear, and the excessive fibrous tissue is excised down to the normal cartilage. The skin then is replaced in its normal position and the wound is sutured with fine silk. The skin is made to conform accurately to the convolutions of the cartilage by introducing through the ear fine wire mattress sutures which have included in them bits of moist sea sponge to provide elastic pressure until the skin grows in place against the cartilage (Fig. 169).

Frostbite

Pathology. The ear is affected more often by extreme cold than most other areas of the body (Fig. 170). The cold first produces a hyperemia and then a marked vasoconstriction. The latter, if mild, may give rise to marked edema of the ear and, if prolonged, may produce ulceration and even gangrene.

Treatment. Conservatism is the rule in the treatment of frostbite. In the immediate treatment, the important therapeutic measure is to stop the exposure to cold. To rub the part with snow or ice, as is so commonly done, is a crude and an ineffective method of therapy. In mild cases, the vasoconstriction is relieved as soon as exposure to cold ceases, and there follows an intense hyperemia with itching and prickling sensations. In moderately severe cases, there is definite swelling with the formation of large bullae, and the appearance is similar to that of a second-degree burn. Simple protection of the part from infection will usually result in healing. In the most severe cases, the vasoconstriction may lead to necrosis and gangrene of the superficial tissues. In the ear, however, sufficient collateral circulation will usually develop to permit spontaneous healing, and simple protective dressings are generally the only treatment needed.



Fig. 170. Frostbite of the ear. Note the edema of the tissues of the auricle.

Furuncles

Furuncles of the ear are not uncommon infections of the external auditory canal in adults. They are extremely painful in relation to their size, because they arise in the hair follicles and so produce tension on the tightly stretched skin of the ear canal.

Treatment. These infections usually

can be aborted by penicillin injections. If the furuncle is not seen until late, local applications of heat will hasten suppuration. When pointing has occurred, relief of pain may be obtained by draining the necrotic point with a small curved pointed knife. As a rule, anesthesia is not necessary for this incision if the patient is told about it before it is made. Warm irrigations two or three times a day will favor drainage of the furuncle. A simple cotton packing of the ear with a little mercurial ointment over the area of the furuncle is all the dressing that is necessary.

Congenital Preauricular Sinus

Etiology. Congenital sinuses appearing in front of the ear (Fig. 171) are a troublesome and a not too common surgical lesion. They result from a faulty closure of the first branchial cleft and are made up of a sinus tract composed of squamous epithelium containing hair follicles and other elements of normal skin which leads to a blind pouch lined with columnar epithelium.[3,17] The sinus has a small opening just in front of the ear and usually leads forward or upward in the subcutaneous tissues to end in the blind pouch, which lies deep in the subcutaneous tissues.

Diagnosis. The sinus is congenital and, therefore, may be noticeable at birth, but usually it is not seen until the tract becomes infected. When infection develops, it appears most often in the blind end of the tract and, being some distance away from the ear, the connection between the swelling and the preauricular sinus opening may not be recognized. Often the lesions may be mistaken for an infected cyst and a simple incision is made, or the abscess may drain through the sinus opening or rupture on the surface of the skin spontaneously.

Treatment. Cure of a preauricular sinus requires a careful dissection and excision of the entire sinus tract. When there is no infection, this operation may be performed under local anesthesia as a primary treatment. When infection is present, drainage of the abscess should be the primary therapeutic measure. The abscess may be incised under local infiltration anesthesia, and, when the infection has subsided, excision of the tract should be performed. In excising these tracts, procaine solution containing



Fig. 171. Congenital preauricular sinus. (*Left*) The opening of the sinus appears just anterior to the upper portion of the ear. (*Right*) The probe outlines the extent of the sinus.





FIG. 172 (*Left*) Keloid of the ear following puncture of the lobe.
FIG. 173 (*Right*). Sebaceous cyst on the posterior surface of the ear.

epinephrine aids materially in obtaining the hemostasis so necessary to permit a careful and an accurate dissection of the epithelium-lined tract.

It is important to remove the entire tract, and for this purpose some method of identifying it is a considerable aid. In some cases, it may be outlined entirely with a probe; in others, it may be necessary to inject the tract with methylene blue in order to identify its ramifications completely. If the latter is to be done, it is wise to make the injection a day before the operation is to be performed. This avoids the confusion which results from staining the tissues if freshly injected methylene blue leaks into the wound during the excision.

After the excision of the entire sinus tract, the wound may be closed with buried sutures of fine silk and the skin closed with interrupted sutures of horsehair, silk or fine steel wire. A Whitehead's varnish cocoon dressing may be applied, or, if there is any question about hemostasis, a pressure dressing and a bandage may be used in addition for 24 hours. Excision is the only method of any value in the treatment of these congenital sinuses.

EAR PUNCTURE

Puncture of the ear for earrings is still requested occasionally. This operation may be performed under local anesthesia after first carefully marking symmetrical points on the center of the ear lobes. The purpose of the puncture is to form an epithelium-lined tract through the lobe. A medium-sized silk thread is drawn through it with a skin needle at the point marked, and is tied loosely in a loop round the lobe. Bleeding is controlled by simple compression of the lobe between the fingers. The suture is moved slightly through the puncture wound at frequent intervals until complete epithelization of the tract has occurred. The suture may then be removed. Negresses must be warned of the possibility of keloid development in the puncture wound (Fig. 172).

Dermoid Cysts

Diagnosis. The area behind the ear is a frequent site of dermoid cysts. These result from an infolding of ectoderm at the lines of embryonic fusion, and they may be diagnosed easily if the cyst is found to be attached deeply and, therefore, not movable over the underlying tissues. Not infrequently, the cyst may also have a rather broad attachment to the under layer of the skin without any intervening subcutaneous tissue. The diagnosis is important because of the difficulty which may be experienced in excision, due to its very firm attachment to the periosteum (Fig. 156). The cyst must be differentiated from the simple sebaceous cyst which is commonly found in this region. Indications for treatment of dermoids of the ear are prominence of the cyst with consequent disfigurement and infection.

Treatment. The treatment of simple cysts is excision. This operation may be performed under infiltration and field block anesthesia. It is important to carry the infiltration deep in these cases, in order to anesthetize the deep

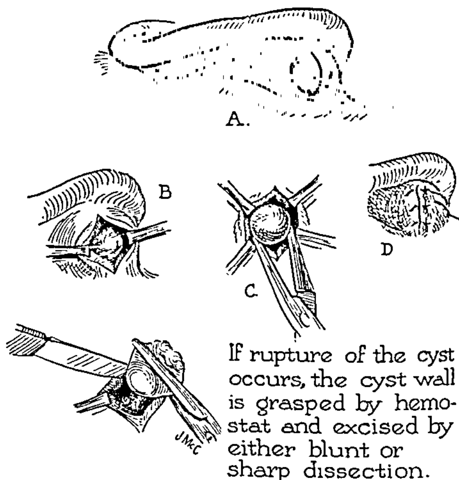


Fig 174 Excision of a postauricular sebaceous cyst.

attachment of the cyst and to provide epinephrine hemostasis for the deeper portions of the wound. Excision of the cyst is best performed through an incision parallel to the cephalic border of the ear. Retraction, combined with blunt dissection, will expose the superficial portion of the cyst, but sharp dissection with a knife is required to remove the deeper portions which are attached to the periosteum over the mastoid region.

Sebaceous Cysts

Sebaceous cysts are noticed very commonly in the region behind the lobe of the ear and along its posterior surface (Fig. 173). These often appear as small bb-shot hard nodules in the ear lobe, and because the patient is conscious of them, they are squeezed and thus often traumatized. They frequently become infected. As time goes on, the cysts fill with sebaceous material and may become as large as marbles before the patient seeks their removal.

Treatment. Removal of the cyst is a relatively easy procedure under local anesthesia (Fig. 174), the surgeon should bear in mind that the nerve supply comes from below upward and along the side in this area. The good blood supply of the ear suggests the use of epinephrine in the procaine in order to control the bleeding. After simple cysts have been enucleated, the wound is closed and a simple dressing is applied. Usually Whitehead's varnish is used.

In those cysts in which infection has appeared, enucleation of the cyst is often not possible, and all that is attempted is simple incision and drainage through a line infiltration of local anesthesia. In many instances, the cyst wall may be removed through such an incision, since it lies surrounded by a pocket of pus. Often, however, it cannot be shelled out and it is unwise to attempt its removal in the presence of an infection. In lieu of removal, the base of the wound may be cauterized with pure phenol, followed by alcohol. Usually no sutures are inserted; the wound is packed with a small gauze drain. This is removed in a day or two and the wound is permitted to heal by granulation. A very inconspicuous scar results.

The dressings for ear-lobe incisions are best applied with a small piece of gauze over the wound and adhesive extending from the front of the lobe to the posterior surface of the ear.

It is wise not to promise patients with infected sebaceous cysts that there will be no recurrence. Cysts are not uncommon in this region, and they may reappear should the scar from operation close the drainage ducts of remaining glands. Therefore, a series of sebaceous cysts is frequently seen.



Fig. 175. Fibroma of the ear.

Benign Surface Tumors

Small benign tumors are not infrequently seen arising from the ear. These may appear early in life as congenital malformations, little polypoid bits of skin or subcutaneous tissue. They can be removed without difficulty by either excision or ligature. Other benign tumors may appear in this area; fibromas (Fig. 175) and lipomas are those most frequently seen. They are easily removed under local anesthesia.

Cutaneous Carcinoma

In older people, the external ear is a common site of the basal-cell type of carcinoma. The original lesion is usually a patch of senile keratosis along the edge of the auricle. As time goes on, small scabs form; these the patient picks off and eventually a small ulcer results.

Treatment. Usually, these basal-cell lesions are easily destroyed by either electrocoagulation or radiation therapy. Either treatment may be carried out on the ambulatory patient.



Fig 176. Furuncle of the eyebrow. Note the edema of of the upper lid.

THE EYE

Stye, or Hordeolum

The furuncular infection of the border of the eyelid is termed a stye, or hordeolum. These infections are often recurrent and, in such cases, there may be some visual defect which is an etiologic factor. For this reason, these patients should be referred to an ophthalmologist for examination

Treatment. The infection is a simple localized staphylococcal infection which responds rather more rapidly than do other furuncles to local applications of moist heat. Hot boric acid compresses are most often used. They are applied for 15 minutes at a time and repeated every second hour. At night and between periods of compress application, an ointment applied along the lid margin will prevent crusting and permit drainage if pus has formed. Surgery is rarely necessary in the treatment of styes. Little is accomplished by incision in either relieving the pain or shortening the course of the infection. In cases of recurrent styes, penicillin ointments and penicillin systemically are of value.

Furunculosis of the Eyebrow

Another staphylococcal infection in the region of the eye is furuncle of the eyebrow. The important feature of this lesion is the marked swelling of the upper lid which accompanies furunculosis in this area. This swelling must not be interpreted as evidence of serious progress of the lesion, the explanation is the abundance of loose areolar tissue of the upper lid which favors its development (Fig

176). Usually, this lesion responds well to hot moist applications and to penicillin.

Foreign Bodies

A common ophthalmologic complaint is a foreign body in the eye. This may be an eyelash, a bit of dust or dirt, a particle of metal or a bit of an emery wheel which flies up in the person's face during the course of his occupation.[14] The foreign body may lie free on the surface of the globe or it may be found in one of the conjunctival sacs. It may be adherent to the surface of the eyeball, may have become embedded somewhat, or may have penetrated to any of the various deeper structures of the eye. The symptoms are pain, often referred to the undersurface of the lid, excessive lacrimation and perhaps photophobia. The conjunctiva may be injected.

Examination. In examining the eye for a foreign body, one should have the patient sit facing a good light. The examiner may stand either behind or to the side of the patient. The lower conjunctival sac may be exposed by traction on the lower lid by the examiner's finger while the patient looks up. The upper conjunctival sac may be examined by grasping the lashes of the upper lid and drawing it down and away from the globe as the patient looks downward. A swab stick or similar object is placed along the upper lid, which is everted over the swab stick. The lid may be held everted in this position by the examiner's finger without discomfort to the patient. If the lower lid is drawn down at the same time, the conjunctival surface is well exposed and may be examined adequately as the patient rotates his eyes in various positions.

If the foreign body is not evident by this examination, it may be revealed by oblique illumination. This is accomplished by interposing a condensing lens between the eye and a source of light somewhere to the side of the patient. A bright spot of light may thus be concentrated in a small area. If the examiner now uses a loupe or some other source of magnification, he may be able to detect a small foreign body. Another aid in identifying foreign bodies or corneal abrasions is the use of 2 per cent fluorescein. A drop of this solution is placed in the eye. The excess is washed out in a few minutes, and any corneal defect will remain stained a greenish color. Preliminary application of some local anesthetic solution such as Pontocaine 0.5 per cent may be of aid in examining for or removing foreign bodies.

Removal. A foreign body may be removed by simple irrigation if it is free in the conjunctival sac or lightly adherent to the globe. If this method fails, a cotton swab is moistened with saline and an attempt is made to mop off the foreign body. In some cases, the particle, though superficial, is so embedded that a blunt spud or some other instrument must be employed to lift it out. In such cases and in all those of deeply penetrating objects, treatment by a competent ophthalmologist is recommended.

The after-care of minor cases consists in frequent irrigations with boric acid solution with the application of bichloride ointment, 1:3,000, between irrigations. Homatropine, 1 to 2 per cent, may be used to keep the eye at rest and a patch applied to protect it.

Corneal Abrasions

Corneal abrasions, such as those due to a scratch by a fingernail or the twig of a tree, require the care accorded the

eye following the removal of a foreign body.

BURNS

In burns due to chemicals, the eye should immediately be irrigated freely with water. This seems to be preferable to the former practice of attempting to neutralize the causative agent, thereby introducing further chemicals and perhaps irritating an already damaged eye. Cold compresses may be applied following burns; otherwise the care is similar to that outlined above for foreign bodies. A mydriatic should be used. Serious burns and abrasions, as well as deeply embedded foreign bodies, demand the care of an ophthalmologist.

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Mouth and Salivary Glands

THE LIP

The inner, or buccal, surface of the lip is occasionally the site of retention cysts of the mucous glands, of papillomas and of other types of benign tumors.

MUCOCELES

A mucocele is a retention cyst of the mucous glands within the mouth. It is commonly found on the inner surface of the lips, on the inner surface of the cheek, in the line of occlusion of the teeth. It may even occur on the dorsum of the tongue. Distention of the ducts of the glands of Blandin beneath the tip of the tongue may cause swelling of considerable size. This cyst occurs most frequently on the lower lip and appears as a soft, even, bluish swelling which frequently varies in size, discharging its contents into the mouth (Fig. 177). It produces symptoms due to its presence on the lip, causing a thickness and protrusion, and not infrequently it is bitten inadvertently by the patient. It causes no pain and almost never becomes infected. The only indications for treatment are the inconvenience and the disfigurement which it produces.

Treatment. The mucocele may be treated by excision, by marsupialization or by injection. Any one of these operations may be performed under local anesthesia.

In excision, after infiltration with 0.5 per cent procaine-epinephrine solution round and underneath the cyst, an assistant should evert the lip and hold the cyst firmly on each side between his thumbs and index fingers. A vertical incision is then made over the surface of the cyst and, if it is carefully performed, the mucous membrane may be divided without cutting the cyst wall. Allis forceps may then be placed on the mucous membrane on each side of the incision, and, with the tension produced, the cyst wall separates from the surrounding tissues with gentle hemostat dissection. The deeper portions of the cyst are somewhat more adherent to surrounding structures, but, by careful dissection, the cyst may be removed intact. If rupture occurs, it usually



FIG. 177. Mucocele of the lower lip.

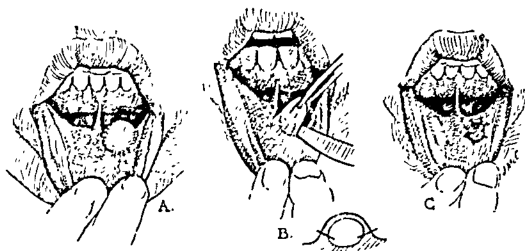


FIG. 178 Marsupialization of a mucocele. (A) The appearance of the mucocele. (B) Excision of the mucous membrane and the cyst wall over the prominence of the cyst. (C) Method of uniting the mucosa of the lip with the epithelium of the cyst with fine interrupted sutures of silk.

takes place in the deepest part of the cyst, a considerable amount of thick, tenacious mucus being evacuated. When this has been wiped away, the remaining portion of the cyst may be removed by sharp dissection.

The wound should be closed with several interrupted sutures of fine silk, so placed as to catch the whole circumference of the wound. The sutures may be removed in 5 to 7 days. Frequently, they will untie and be removed by the tongue of the patient, or they may slough out if they are very superficial. Nevertheless, the wounds heal kindly.

In treatment by marsupialization, the mucous membrane and the bulging dome of the cyst wall are excised together so as to lay open the epithelium of the mucocele on the surface of the lip (Fig. 178). A few sutures joining cyst wall and mucosa are usually inserted. At times the floor of the cyst may be cauterized with Carnoy's solution (p. 17) or trichloracetic acid.

Recurrence of a mucocele is not uncommon, and it is most likely to take place when the cyst has been treated by marsupialization.

The object of the injection treatment of mucous cysts is to produce a fibrous obliteration of the cyst cavity after aspiration of its contents and the injection of a sclerosing solution. Carabba[7] recommends aspiration of the cyst and the injection of 0.5 cc. of his sclerosing solution (p. 17). An 18-gauge needle should be used to aspirate the heavy mucus from the cyst cavity. The cyst cavity is obliterated within a week and a hard pea-sized nodule forms; this disappears gradually over a period of 3 to 4 weeks. In most cases, a single injection is sufficient. The author has used Carabba's method in many cases with satisfactory results.

Papillomas and Fibromas of the Lip

The lip is occasionally the site of papillomas and fibromas (Figs. 179 & 180). Most often they appear on the mucous surface of the lip just within





FIG 179 (*Left*). Fibroma   FIG. 180 (*Right*). Papilloma of the lip.

the vermilion border, and, except that they are annoying and disfiguring, and may become polypoid (Fig. 181), they cause no symptoms. They may be excised under local anesthesia and the wound sutured with fine silk.

DENTAL PLATE ULCERS OF LIP AND CHEEK

Not infrequently, chronic ulcers of the mucous membrane may occur due to the trauma caused by an ill fitting dental plate. Almost invariably, these ulcers occur in edentulous individuals in whom absorption of the alveolar process has permitted the edge of the plate to press into the soft tissue. This chronic trauma eventually produces a painful ulceration, usually noted in the sulcus between the cheek and the gum (Fig 182). The lesion is frequently mistaken for carcinoma, but on careful examination it is found to be a simple local ulcer with little or no surrounding induration. The pain is relieved at once by the removal of the offending plate The ulcer usually heals spontaneously if the plate is removed for a few days or if the portion of the plate causing the pressure trauma is removed.



FIG. 181. Polypoid fibroma of the lip.

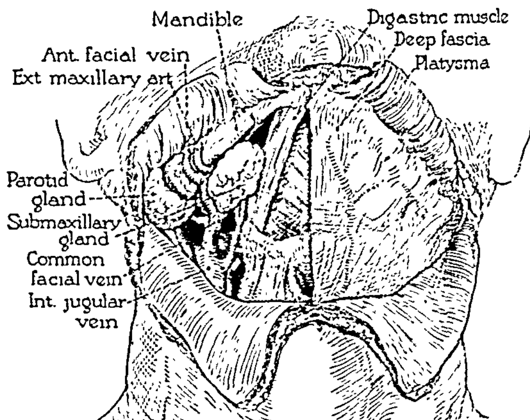


FIG. 185 Anatomic drawing of floor of mouth from underneath. On the left side, the platysma has been folded back, but the deep fascia remains. On the right, the deep fascia has been reflected to show the relations of the submaxillary gland, the parotid gland and the digastric muscle. In the mid line is the hyoid bone.

cysts are apt to interfere somewhat with speech. They may become so extensive as to cause a definite swelling beneath the symphysis. Not infrequently, the obstruction to the outlet of the duct may be intermittent, and the ranulae may therefore vary in size, with the appearance of a salty mucuslike material in the mouth.

Treatment. The treatment of ranulae may be marsupialization, excision of the enlarged duct, occasionally excision of the duct and the sublingual gland, or aspiration and injection of a sclerosing solution. Simple incision or the insertion of a seton to permit drainage of the contents almost invariably results in recurrence.

The operation of marsupialization may be performed easily on an ambulatory patient under local anesthesia. After a local infiltration with procaine-epinephrine solution over and round the cystic swelling, the mucous membrane is divided and retracted gently with silk traction sutures to expose the dome of the cyst. When the dissection has been carried downward to the level of the floor of the mouth, the projecting portion of the cyst is excised. A thick mucuslike material will escape from the cyst. It is well, in excising the dome of the cyst, to catch the lining membrane with several fine silk sutures which pass through the cyst wall and the adjacent mucous

membrane of the floor of the mouth. The entire circumference of the cyst wall thus is sutured to the mucous membrane bit by bit as the projecting portion of the cyst is excised. Sutures are placed about 1/8 inch apart, and they should be left long in order to serve as tractors until all the sutures have been placed. After the insertion of the sutures and before they are cut, the floor of the cyst may be spread out by traction and cauterized with Carnoy's solution or 50 per cent trichloracetic acid. During the operation, a small suction apparatus is of great help in keeping the field free of blood and saliva. Usually, little bleeding is encountered, and the only postoperative care necessary is the use of warm saline mouthwashes.

The prognosis must be guarded, even in cases in which a large opening seems to have been left after marsupialization, for ranulae occur frequently.

The most simple method of treatment of ranulae is aspiration and injection of a sclerosing solution. Carabba[7] has reported cures by this method, and the author has used it with excellent results on numerous occasions, several times for recurrence following operation. The ranula is aspirated and injected as described for mucous cysts (p. 272).



Fig. 186. Ranula. In this patient, the ranula recurred following marsupialization and was cured by injections of sclerosing solution.

Salivary Calculi

Etiology. Calculi occur frequently in the submaxillary gland ducts, but rarely in those of the parotid and the sublingual glands. Calculi may be present in both the glands and the ducts. The cause of the calculus formation has been variously ascribed to inflammation and infection, and Soderlund[21] and Naeslund[17] have isolated actinomyces from the stones. They believe that calcium salts are deposited about colonies of this fungus by reason of a change in hydrogen ion concentration. The actinomyces found were often saprophytic forms, hence the occurrence of calculi without the presence of the usual symptoms of actinomycosis in the tissue.

Symptoms. The symptoms of a stone in the submaxillary duct are typical and characteristic, but, in spite of this, the patient is often treated for long periods for toothache, lingual neuralgia, lymphadenitis or malignancy. The presence of the stone causes an intermittent, or often a complete, obstruction of the duct. The result is a painful swelling in the region of the submaxillary gland just below the angle of the jaw (Fig. 187). The symptoms are most marked at mealtimes, when functional engorgement occurs and back pressure on the gland increases. In intermittent obstruction, the patient often notes the discharge into the mouth of a salty material with subsequent relief of pain in the gland.

On examination during an acute



Fig. 187. Calculus of the submaxillary gland (*Left*) Note swelling over the calculus at the distal end of the submaxillary duct in the floor of the mouth. (*Right*) Enlargement of the gland which occurs when the duct is blocked by a calculus.



Fig. 188 Roentgenogram of floor of mouth, showing a salivary calculus.

attack, a tender edematous swelling may be noted along the course of Wharton's duct on the involved side. At times the stone may be associated with a purulent infection of the duct. In such cases, the outlet of the duct (sublingual caruncle) may be reddened and pus may be expressed from it.

Diagnosis. In the majority of cases, the stone lies in the anterior two thirds of the duct, and usually it may be palpated along the course of the duct with one finger in the mouth and another under the chin. In a few cases, the stone may be found presenting at the orifice of the duct. If the stone cannot be palpated, a roentgen examination frequently will reveal its presence and location. Occlusal bite



Fig. 189. Three salivary calculi removed from the distal portions of submaxillary ducts in ambulatory patients

films will show the stones in the submaxillary duct to best advantage (Fig. 188), while stones in the gland proper are shown by lateral film exposures.[11]

Treatment. The treatment of submaxillary calculus is removal of the stone. This is a relatively easy procedure if the stone is large and lies in the anterior two thirds of the duct. Several procedures may be followed.

In incision, under local infiltration or mandibular or lingual block anesthesia, the mucous membrane is divided over the calculus, exposing the duct. Incision of the duct permits removal of the calculus (Fig. 189). When the stone is small and movable, Ivy and Curtis[13] recommend the insertion of a fine silk suture round the duct behind the calculus. Traction upon the suture closes the duct and prevents the calculus from slipping back toward the gland during the operation. The suture is removed after it has served its purpose.

Beck[5] obtains immobilization of the duct by inserting two silk traction sutures through the orifice of the duct. These may be held by an assistant, or they may be hooked between the teeth so as to convert the duct orifice into a fairly large slit. The duct then is cut open until the stone is reached. Some authors[8] recommend the use of the electric knife to avoid bleeding. This technic is most valuable for stones in the anterior one third of the duct.

After removal of the stone, the mucous membrane may be closed with fine silk sutures or it may be left open. Usually, no sutures are inserted if there has been an associated infection of the duct, and the postoperative ooze may demand a small pack in the wound. Postoperatively, hot mouthwashes are of value for several days. For the first 24 hours, a sedative may be necessary, although usually relief of pain and discomfort is almost immediate after removal of the calculous obstruction.

When the calculus lies in the posterior one third of the duct or at its junction with the gland, hospitalization is advised; usually the gland, as well as the calculus, has to be removed through an external incision. It is a more formidable procedure because of the important anatomic structures surrounding the gland.

Dilatation of the duct is another method. Ballon and Ballon[4] have reported cases in which they were able to dilate the submaxillary duct enough to allow the calculus to be extruded through its orifice. They recommend this procedure when, for some reason, operation is inadvisable or will not be permitted by the patient.

Salivary Fistulas

Among the distressing sequels of traumatic injuries to the cheek is a fistula of Stensen's duct. Cutting injuries which pass through the cheek below the zygoma must always be investigated carefully in order to avoid this complication. Repair of the soft-tissue wound without repair of Stensen's duct occasionally leads to a constantly draining salivary fistula, in which the flow of saliva is increased by the usual stimuli of salivary secretion.

Prophylaxis. Immediate repair of the severed duct usually prevents secondary fistula formation. Suture of the duct is best performed with split silk sutures, but the important part of the procedure is the insertion of a dowel through the duct, uniting its portions. It is probable that, with a dowel in place, the wound in the duct need not be sutured at all. Brohn and

Bird[6] suggest the use of a filiform bougie inserted through the orifice of the duct, joining its severed portions. They stress the importance of anchoring the dowel in place by tying it to an upper canine tooth or by passing it through a tiny wound in the cheek and suturing it to the skin. The saliva from the gland drains round the filiform, and the bougie prevents obstruction to the duct by the ingrowth of scar tissue. The dowel may be removed in a week.

Glascock and Glascock[12] report an ingenious method for the insertion of a silkworm dowel. A fine metal probe is inserted through the orifice of the duct and made to emerge in the wound of the cheek. A long loop of silk thread is wrapped round the end of the probe and pulled back so that the loop enters the mouth. A heavy piece of silkworm gut is bent, hooked into the loop of silk, pulled through the distal portion of the duct and made to emerge through the wound in the cheek. The patient then is given some lemon juice to stimulate the salivary flow; in this way the proximal end of the duct is identified. The same probe is inserted through it, forced through the parotid gland and made to emerge underneath the skin. A small nick is made in the skin to permit the probe to emerge on its surface. The loop of silk is again fastened to the probe and drawn back into the cheek wound. The end of the silkworm gut is again hooked in the loop of thread, drawn through the gland portion of the duct and made to emerge on the skin surface. The ends of the silkworm gut are anchored in place with lead shot, and the gut is allowed to remain in place for a period of 4 weeks. Bailey and Skaff[3] report a similar procedure using a No. 10 cotton or heavy silk thread.

After the dowel has been placed in the duct, the soft-tissue wound in the skin is closed tightly with horsehair sutures. The entire operation may be performed under local anesthesia.

Diagnosis. In chronic salivary fistulas, the diagnosis is usually made by the increased secretion at times of salivary stimulation and by the history of an injury to the cheek in the region of Stensen's duct. That the secretion is saliva may be confirmed by observing that it digests starch solution. The starch solution becomes clear, and the bluish color produced by iodine changes to the red reaction obtained when dextrins are formed.

Treatment. Repair of a chronic salivary fistula may be somewhat more difficult because of the scar tissue formed round the fistulous opening. It may be carried out, however, along the same lines as described above. Another form of therapy which must be considered in the treatment of chronic salivary fistulas is the suppression of salivary secretions by roentgen irradiation to the area of the parotid gland. Favorable results have been reported by this method of therapy.[20]

Parotitis

Anatomy. The parotid is a compound racemose gland which lies on the posterior half of the masseter muscle between the ear and the angle of the jaw. Its secretion is carried to the mouth through Stensen's duct, which rises from the upper anterior portion of the gland and passes almost horizontally to empty through an easily visualized papilla opposite the upper second molar. It is enclosed so snugly in the dense parotid fascia that

swelling produces marked tension and, therefore, marked pain.

Etiology and Symptoms. The gland becomes infected usually through an ascending spread of organisms along the duct. The most common form of parotitis is the acute pyogenic type, which often follows operation or debilitating disease. This type of parotitis is not under discussion for the ambulatory patient. There is, however, a type of recurrent chronic parotitis which may be seen and treated in office practice.[18] It is characterized by a swelling of the parotid gland which may last several hours, days or even weeks. In some instances, the swelling may be present in the morning and disappear after eating. The secretion from the gland may not be altered, although on occasions some patients may note an excessive discharge of pus and saliva from the infected gland. Often the discomfort occasioned by the swelling may be relieved by pressure over the gland or the duct. There is usually no febrile reaction and no impairment of the general health.

Apparently, there is no definite cause for this chronic parotitis, although cases are reported which would suggest that dental infection, tonsillitis, sinusitis or the inadequate cleansing of dentures may be predisposing causes.

Diagnosis. On examination, the involved gland is found to be enlarged, firm, often nodular, and usually slightly tender to pressure. Pressure along the duct or over the gland may often produce a discharge of cloudy saliva, a mass of thick mucus, fibrin or even pus It is important to be sure that no stone is obstructing the duct. The diagnosis of calculus may easily be made by roentgenography.

Treatment. The treatment of chronic recurring parotitis consists in attempting to obtain a free flow of saliva by stimulation of the glands and by gentle dilatation of the ducts. In addition, attention must be paid to the eradication of any focal infection in the mouth. Infected teeth and tonsils should receive appropriate treatment. In many cases, simple massage of the gland and stimulation of the salivary flow by mastication or by taking a small amount of lemon juice in the mouth will be sufficient to prevent obstruction of the duct and to produce a subsidence of the symptoms. In most cases, dilatation of the duct is advisable. This may be accomplished by the insertion of whalebone filiforms of gradually increasing size. The cheek is grasped with gauze and the orifice of Stensen's duct is located opposite the upper second molar tooth. A filiform then is inserted through the meatus into the duct until it is stopped by the edge of the masseter muscle. If the cheek then is pulled forward, the duct straightens out and the filiform can pass backward to the gland. By the use of larger filiforms, the duct is dilated gradually. Usually, little pain is caused by this maneuver.

Payne[19] recommends the injection of iodized oil in the duct with a 22- or 20-gauge round-tipped needle. The injection of the oil produces a dilatation of the duct and apparently has a beneficial effect upon the infectious process In addition, Lugol's solution, 20 minims every 3 hours, may be given by mouth, as suggested by Leithauser and Cantor.[14] The excretion of the iodine by the parotid exerts the same local antiseptic action that urinary antiseptics do in cases of genito-urinary infections. The antibiotics, usually

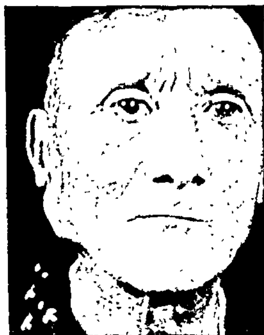


Fig. 190. Mixed tumor of the parotid gland.

penicillin, give excellent results in controlling parotid infection in both the acute and the chronic forms.

Mixed Tumors of the Salivary Glands

Mixed tumors are a peculiar group of tumors which occur chiefly in the parotid region, less often in the other salivary glands, in the palatal region and in the lip. They are considered to be benign; there is a definite tendency for local recurrence, though only rarely with malignant degeneration.

Etiology. Most likely mixed tumors

probably epithelial in origin, the cells arising from the ducts or the secreting portions of the gland. They often contain mucoid material which Fry[10] considers to be a true secretion of mucin from the tumor cells For a time, cartilage was believed to be present in these tumors, but Fry's studies have shown that this is not so. The substance which was mistaken for cartilage is, in reality, mucin which has lost its fibrillar appearance and its power of deep staining in microscopic sections.

Diagnosis. These tumors may occur at any age and in either sex. They are more apt to appear before the age of 40. They are seen over the parotid gland or below and behind the angle of the jaw as a slow-growing, hard, often nodular, swelling (Fig 190). As a rule, little or no pain is experienced by the patient.

A differential diagnosis must be made between mixed tumors and carcinoma or sarcoma. Most of the latter tumors can be differentiated by the rapidity of growth: they reach a fair size in a period of months rather than years. Pain is a much more common symptom in the true malignant tumors.

Treatment. Patients usually seek treatment because of the appearance of the swelling in front of or below the ear, and, in cases of typical mixed tumors, removal of the tumor is the most effective treatment.

The excision of a mixed tumor of the parotid can be performed easily under local anesthesia in an ambulatory patient. In such operations, the course of the facial nerve must be borne in mind; careful enucleation of the tumor in its capsule will prevent injury to it A transverse incision is usually made through the skin and the subcutaneous tissues overlying the tumor mass. After dividing the tissue over the capsule, the dissection is carried on bluntly until the mass is shelled out. In small tumors, the operation is relatively easy to perform

without rupture of the tumor. In larger tumors, cystic softening may result in easy rupture of the tumor capsule. In such cases, the material which spills from the tumor into the wound must be carefully removed, and, after enucleation of the tumor, the wound should be flushed with hot saline to remove any bits of tissue which might reseed tumor cells. The wound cavity is obliterated with several layers of fine sutures and the skin is closed with horsehair. No drain is inserted into the wound. As a rule, a Whitehead's varnish cocoon dressing is placed over the wound and a pressure bandage is applied for 3 or 4 days. The chief postoperative complication to be feared is a facial nerve paralysis. This is easily avoided if the dissection is performed bluntly and is carried carefully round the capsule of the tumor. After operation, the patient should be inspected for evidences of paralysis, which most often appears at the angle of the mouth, usually at the outer portion of the lower lip. As a rule, this immediate paralysis is due to a block of the lower branches of the facial nerve by procaine. This disappears with the loss of anesthesia.

Although the patient may have no paralysis immediately after operation, an almost complete facial paralysis may appear during the first 24 hours. Most often this is due to the pressure of retraction at operation and the subsequent edema in the wound. In every case in which paralysis has occurred in the author's experience, spontaneous recovery has taken place in a relatively short period.

Irradiation has been used in the treatment of mixed tumors of the parotid, but experience in a number of these has confirmed McFarland's conclusion[16] that irradiation has not yet been shown to be of any benefit. Of course, this is not true of malignant tumors, and there is perhaps some evidence that malignant tumors and recurrences are influenced favorably by radiation therapy.

Prognosis. The prognosis of mixed tumors is good, but cure is not always certain. Recurrences may take place any time up to 30 years after operation (McFarland)[16] and may be as high as 20 to 40 per cent. On the other hand, recurrences are usually local. Trueblood,[21] State[22] and Ariel, Jerome and Pack[1] believe that all mixed tumors are potentially malignant and that the parotid gland should be subjected to radical extirpation, the facial nerve being preserved. This would appear to be more radical therapy than the danger of malignancy warrants, and the danger of facial paralysis is great. In the author's experience, mixed tumors have nearly always been benign. Malignant changes producing metastasis are rare. Secondary excision of recurrences is often performed with more difficulty than is encountered in the original operation. It is perhaps wise to give a course of preoperative irradiation before excision is attempted.

THE TONGUE

Lacerations

Lacerations of the tongue may occur due to bites incidental to falls, convulsions and so forth; or, in the case of children, to falls sustained when they have an object in the mouth. As a rule, small simple lacerations which do not pass through the tongue or do not involve the edge of the tongue may be treated conservatively. Suture is rarely necessary except to control bleeding. Lacerations which involve



Fig 191. Fibroma of the tongue.

the edge of the tongue, so that a flap of tongue substance is formed, are best treated by suture. These may be inserted after infiltration with procaine-epinephrine solution. The sutures are placed with small curved cutting-edge needles and should include one half the thickness of the tongue. This means, therefore, that corresponding sutures should be inserted on the upper and the lower surfaces of the tongue and on the edge of the tongue. They should be of fine silk. In spite of the abundant bacterial flora of the mouth, wounds of the tongue usually heal primarily when sutured. Mouthwashes are useful during the first few days after the insertion of sutures, which may be removed when they become loose, often as early as the third or the fourth day

Acute Inflammations

Acute inflammations of the tongue occur rather infrequently as the result of wounds or of an extension of an acute infectious process from the throat. These inflammations are associated with salivation and marked swelling of the tongue. They may subside spontaneously, may form a local abscess or, occasionally, may lead to death. Only the milder cases can be safely treated in the ambulatory patient. The severe cases and those with abscess formation demand hospital care. In milder cases, the glossitis may subside by the use of hot mouthwashes, cessation of talking and the limitation of fluids. If a patient with glossitis becomes worse during 24 hours of observation, hospital care should be recommended.

Tonguetie

A congenital shortening of the frenum of the tongue is a rather uncommon but easily treated abnormality. This deformity is usually noted in infancy or childhood. The parents become aware of it because of the inability of the child to stick out his tongue or because of an impediment in his speech.

On examination, the short lingual frenum is at once apparent. Often the tongue cannot be protruded beyond the teeth, and, during efforts to extend it, the tip is pulled down and the body bulges upward in the mouth.

Treatment. The treatment of tonguetie is incision of the shortened frenum. This operation may be performed in infants without anesthesia, but in older children local infiltration anesthesia is advisable. This should be made toward the floor of the mouth. Using the broad end of an ordinary grooved director as a retractor, the frenum may be slipped into its central slot and so isolated as to make it easily visible. It is then divided with scissors, care being taken not to carry the incision too far backward because of the danger of injur-

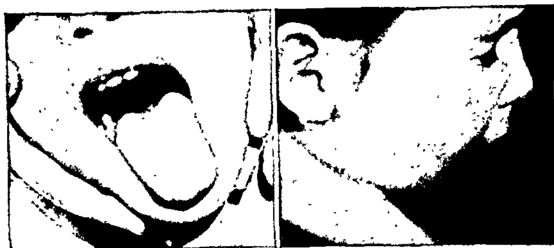


FIG. 192. Hemangiomas (*left*) on the dorsum of the tongue and (*right*) on the anterior portion of the tongue.

ing the frenal artery. The small amount of bleeding which occurs usually stops without active treatment.

BENIGN TUMORS

Fibromas and Papillomas. The tongue may be the seat of small papillomas or fibromas (Fig. 191). These are seen most commonly in the anterior half of the tongue and usually cause no symptoms except annoyance to the patient. Occasionally, they become pedunculated. They may be excised easily under local anesthesia, the wound closed and the bleeding controlled by one or two sutures of fine silk.

Hemangiomas. The tongue is a rather uncommon site for hemangiomas. When they do occur, however, they usually are of the cavernous type (p. 195, Fig. 192) and may be treated by injection, by electrocoagulation or by the insertion of radon seeds (pp. 196-197).

THYROGLOSSAL CYSTS

The nonobliterated thyroglossal duct, which passes from the foramen cecum at the base of the tongue obliquely downward and forward to the isthmus of the thyroid gland, is not infrequently the site of a cystic enlargement. These cysts commonly present in the mid-line of the neck, but occasionally the upper part of the duct may dilate and form a cyst at the base of the tongue. This lesion is mentioned only from the point of view of diagnosis, because excision of this cyst when in the base of the tongue demands more in the way of anesthesia and operative manipulation than can be performed in an ambulatory patient. (See Thyroglossal Cyst, p. 315) However, it may be possible to treat such lesions by aspiration and injection of sclerosing solutions (see Carraba's solution, p. 272).

THE ORAL CAVITY

ACUTE DENTO-ALVEOLAR ABSCESSES

Etiology. This abscess is an acute localized infection about a tooth. It usually is the aftermath of the death of the pulp of a tooth and the formation of a suppurative area at its apex which then extends through the al-



Fig. 193. Acute dento-alveolar abscess ("gum boil").

veolus and points externally (Fig. 193). It may represent the acute flare-up of a long-existing chronic inflammation.

Symptoms. In the upper jaw, the abscess usually points on the gum and is commonly known as a gumboil. The offending tooth is decayed and slightly loose, and the surrounding gum tissue is red, swollen and very painful. The tooth is very sensitive to the slightest touch. As the infection progresses, the swelling will fluctuate and require attention. The abscess more often points on the buccal and the labial surfaces of the alveolar process, but it may develop palatally. If the pus perforates above the attachment of the buccinator muscle, it will travel upward and point on the skin of the face. The majority of these abscesses in the lower jaw cause more serious infections, and the patient is hospitalized.

Treatment. Those infections which point within the mouth should be relieved by incision close to the bone, ample drainage with rubber tissue or gauze being used. Vinethene or nitrous oxide may be used as the anesthetic; local anesthesia is usually not suitable. It is often possible to open the abscesses, particularly in the anterior part of the mouth, without any anesthetic. The offending tooth should not be extracted until the acute stage of the disease has subsided. Beginning as soon as there is hemostasis, hot saline mouthwashes are prescribed. The abscess usually drains completely in a day or two. The packing or the drain may be removed, but hot mouthwashes are continued until healing occurs.

Openings from the Mouth into the Antrum

Teeth whose roots have impinged upon the floor of the antrum or have actually perforated it are frequently extracted from the upper jaw; these are, particularly, the molars and the premolars and occasionally the canines. There may or may not have been any periapical infection. An opening, therefore, often exists between the mouth and the antrum through the socket of such a tooth. This opening tends to close if it is not interfered with, but often it remains open with consequent infection of the antrum If this infection can be cleared up under the care of a rhinologist or an oral surgeon, the opening can be closed either by undermining its edges and freshening and suturing them or, if the opening is large, by sliding a flap into it from the palate. These procedures can easily be accomplished under local anesthesia.

Dermoid Cysts

Etiology and Location. Dermoid cysts are infrequently observed in the oral cavity. They are the result of congenital displacement of ectoderm or entoderm, due to incomplete union of the first branchial arch. They are usually found in the mid-line between

and above the genioglossus muscles and beneath the mucous membrane in the anterior floor of the mouth or between the genioglossus and the geniohyoid muscles. Cysts in this location push the tongue upward and often backward, and present in the sublingual area (Fig. 194). They interfere to some extent with the movements of the tongue and with the shape of the mouth. They may also lie between the geniohyoid and the mylohyoid muscles, in which case they present in the submental area (Fig. 195). Eliason[9] states that although these cysts are congenital, they usually are not noticed until they increase in size. They grow very slowly, but may assume considerable size, extending laterally into the submaxillary region or well down into the neck. They are rather firm, feel like soft putty and may contain hair or other epithelial appendages.



Fig. 194. Dermoid cyst in the sublingual area. (Shore, Benjamin Rice: Ann Surg. 108:305 308)

Treatment. The treatment of the cyst is removal. This operation can usually be performed within the mouth, under local anesthesia, incision being made in the mid-line and the tissues being bluntly divided. Smaller cysts may be enucleated with comparative ease. The use of epinephrine in local anesthetics is particularly valuable in reducing the amount of oozing, and a small suction tip, such as is used in brain operations, helps

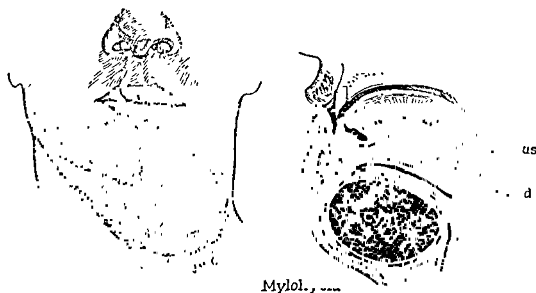


Fig 195 Dermoid cyst of the floor of the mouth presenting in the submental area This cyst lies below the geniohyoid and above the mylohyoid muscle.

materially in keeping the field dry. The sublingual wound may be sutured or packed gently with gauze to prevent oozing. Warm mouthwashes should be used postoperatively. Larger cysts which have extended into the neck may require external incision and are perhaps best treated in the hospital.

CYSTS OF THE JAW BONES

DENTOCYSTIC TUMORS

These are a group of cystic tumors which are the result of the abnormal growth of cells concerned with the formation of teeth. They may be conveniently grouped as follows: (1) dentoperiosteal cysts (radicular); (2) dentigerous cysts (follicular), and (3) ameloblastomas (adamantinomas or multilocular cysts).

Dentoperiosteal Cysts

These are by far the most common, and almost always they involve the roots of devitalized teeth which have become infected following the death of the pulp. The tooth involved may be removed but the cyst will remain and continue to grow; this is spoken of as a residual cyst. These cysts have a fibrous capsule lined with layers of epithelium and remnants of cells of the enamel organ, and they contain a clear, straw-colored fluid with cholesterin. Pus may be found if they are infected. They vary greatly in size, from that of a pea to that of a small lemon. In the upper jaw, they may encroach upon the antrum, and even rupture into it, and also involve other teeth by extension. Small cysts may give no symptoms whatever and are sometimes found only after roentgenray examination. Larger ones may cause a bulging of the bone, usually buccally or labially, less often lingually.

Treatment. The treatment consists of extraction of the tooth or the teeth involved and usually extirpation of the sac and its contents, a mucoperiosteal flap first having been made over the cystic area. The flap may be closed, or it may be tucked into the cavity and the area allowed to granulate and gradually fill in. Occasionally, the lining membrane is left in place and the wound is kept wide open, particularly when there is fear of opening into the antrum.

Dentigerous Cysts

These come from degenerated cells of the enamel organ and contain an unerupted tooth, usually a canine or, next, the mandibular third molar.

Treatment. The symptoms and the treatment are essentially those of the dentoperiosteal cyst. The unerupted tooth is usually extracted, but in certain instances it may be allowed to remain and brought into proper alignment. Operations on the foregoing cysts are usually performed by nerve block with local anesthesia.

Ameloblastomas

These are the least common of the dentocystic tumors. They also arise from the dental epithelium and usually contain many cystic cavities, but in certain stages they may be largely a solid mass of tissue. They usually occur in the angle of the mandible, very rarely in the maxilla. They present a slowly increasing enlargement of the bone in the region involved, usually externally, and are painless, unless secondarily infected. They may extend into the surrounding soft tissues and show a definite swelling of the skin.

Treatment. When small localized areas are involved, conservative treatment by curettement and the application of radium in the cavity is possible, but complete resection of the jaw, well beyond the tumor mass, is usually indicated. This growth is not malignant, but it will recur unless every vestige of epithelium is removed.

Nasopalatine and Hemorrhagic Cysts

Other cysts may occur in the jaw bones, notably nasopalatine and hemorrhagic, or traumatic, cysts. Neither type has its source in the dental epithelium.

Nasopalatine Cysts

Nasopalatine cysts develop in the incisive area of the maxilla and are thought to arise from epithelial remnants of the nasopalatine duct. They may not present any symptoms, but, if they become large enough to cause a bulging in the palate, they may be painful. They do not affect the teeth, and they may be found only by roentgen examination.

The treatment is enucleation under a mucoperiosteal flap in the anterior part of the hard palate.

Hemorrhagic Cysts

Etiology. Hemorrhagic cysts are rare in the jaw bones, but they have occurred in the mandible. They have all been in adolescents and have followed trauma. The blow is not strong enough to produce fracture, but there is apparently a hemorrhage in the bone from which these cystic areas develop. There is a gradual hollowing out of the mandible with sometimes a noticeable external swelling. There is a dull pain in this area, and the radiograph shows a well-defined translucent area in the bone. The neighboring teeth are vital.

Treatment. The treatment consists in opening into the cavity, usually externally, to prevent mouth contamination, and allowing the clear, reddish serous fluid to escape. The wound is kept open a short time and allowed to heal by granulation.

TUMORS

Epulis

The most common tumor in the mouth is the so-called epulis, histologically a fibroma. It develops from the dental periosteum and appears on the gum in an interdental space, varying in size from that of a pea to that of an orange (Fig. 196). There are three types: (1) the simple fibroma, or hard epulis; (2) the fibro-angioma, or soft epulis; and (3) the giant-cell epulis. The fibrous type is hard and covered with normal mucous membrane. The fibro-angioma is soft and very vascular; therefore, it is red and bleeds easily. The giant-cell tumor is quite vascular and is covered with a reddish-purple mucous membrane and usually invades the alveolus by pressure. It may also arise from within the bone and gradually cause expan-



Fig. 196. Epulis.

sion of the inner and the outer plates. Incision into the tumor mass reveals a reddish brown color similar to that of freshly cut liver.

The treatment is curettement well down into the tooth socket and bone, with usually a loss of one or more teeth.

Fibromas

Fibromas may also develop from the periosteum of the bone and appear as slow-growing nodules, firm and covered with normal mucous membrane. They may also appear in the cheeks, the tongue and the lips as firm, painless nodules developing from the underlying connective tissue. The treatment is excision of the encapsulated mass under a mucosal or a mucoperiosteal flap.

Osteomas

Osteomas may be found in both jaws. They develop more in the region of the tuberosities of the maxilla than elsewhere, and appear as hard slow-growing masses covered with normal gum tissue. They can be removed easily under mucoperiosteal flaps by chisels, rongeurs or surgical burs

Calcified Dental Anomalies (Odontomas)

Calcified masses of dental tissue may appear in the jaw bones They are commonly referred to as odontomas, but, since they are not true tumors, are better termed calcified dental anomalies. They vary in size and in shape, are usually deep in the bone and as a rule, give no clinical symptoms. They are extremely dense and should be left alone unless they give rise to pain or ulcerate the overlying gum. They may then be removed—usually with considerable difficulty—in part or in their entirety. It is much easier to remove those in the upper jaw than those in the lower, where they may be frozen into the heavy cortical plates.

Lipomas, Angiomas, Papillomas

Lipomas usually appear on the cheek or the tongue as soft, boggy, even elevations. They are removed by simple excision.

Angiomas may be congenital or acquired, usually are blood vascular in type, and most commonly appear on the tongue and the lips. They present bluish compressible masses of varying size and shape, and sometimes become cavernous in type. They should be eradicated, if possible, because of the possibility of hemorrhage.

The treatment is excision when practicable. Other forms of treatment are electrocoagulation, irradiation and ligation of the vessels. The injection treatment is effective if given in not too large doses; several injections may be necessary.

Papillomas are found most frequently on the tongue and on the cheeks opposite the occlusal surfaces of the teeth. They are localized elevations of the epithelium and are formed, generally, by irritation, as biting the cheek. The treatment is simple excision.

Other tumors, both benign and malignant, occur in the mouth and the jaw bones, but they will not be considered here.

PSEUDOTUMORS

Hypertrophy of Gums and Lips

By simple hypertrophy is meant an outgrowth of tissue due to an enlargement of the cells but with a maintenance of their normal function. For some unknown reason, a generalized

hypertrophy of the gums is seen occasionally in children. The teeth may be nearly covered. There may also be a localized overgrowth of gum tissue about a tooth or encroaching upon a large cavity in a tooth. In adults, there is occasionally seen a very extensive hypertrophy of the gums with fibrous tissue formation and also bone. Such conditions are spoken of as fibromatosis or as osteofibromatosis (Phemister).

Hypertrophy of the gums and of the mucous membrane of the lips is not uncommon in edentulous mouths with poorly fitting artificial dentures. The dentures originally are made to fit the alveolar process following the removal of the teeth. There no longer being teeth in the process, its usefulness is ended and it resorbs. The resulting space in the denture is occupied by soft, flabby hypertrophied tissue, and the plate ceases to fit properly, adding insult to injury and piling up more overgrowth of tissue because of the irritation. This hypertrophy may become very extensive, involving the mucous membrane of the lip as well, and may appear in several overlapping laminae. Occasionally, this tissue becomes ulcerated and consequently very painful.

Treatment. The treatment in all cases is to remove the cause, when known, and then to excise the excess tissue. If the underlying teeth are loose, they should be extracted. In edentulous mouths, new dentures must be constructed. If the tissue is removed properly, recurrence is unusual.

Pregnancy tumor is a specialized angiomatous hypertrophy of the gingiva which occurs occasionally during pregnancy. It is believed to be due to a stimulation caused by hormonal activities associated with pregnancy. Usually, it is made up of granulation tissue showing areas of angiomatous proliferation and epithelial hypertrophy. Removal is necessary if the tumor does not disappear following pregnancy[27] (Fig. 197).



Fig. 197 (*Left*). Pregnancy tumor and gingivitis gravidarum. This tumor appeared in a 34-year-old patient during her fifth month of pregnancy. Microscopic examination showed angiomatous hypertrophy of the gingiva (Thoma, Kurt H., Internat. Abstr. Surg *in* Surg., Gynec. & Obst 67:522-545)

Fig. 198 (*Right*). Leukoplakia of the mouth.

Exostoses

Exostoses, or dense bony excrescences, are found in both jaws.

Torus Palatinus. This is an exostosis of the hard palate in the midline, and it presents a hard oval swelling which varies in size and may be smooth or nodular. It is often mistaken for an osteoma. It is present normally in a certain percentage of people, most of whom never know that it is there. It is painless, does not grow and should be removed only when it interferes with the fitting of a denture or when the overlying mucous membrane becomes irritated.

Torus Mandibularis. This is an exostosis found on the lingual surface of the mandible, usually bilateral, in the region of the canines and the premolars. Indications for removal are similar to those in the case of torus palatinus.

Exostoses may be found frequently in the region of the tuberosities of the maxilla and occasionally in other areas. If removal is indicated, the bone may be trimmed away with bur and chisel under a mucoperiosteal flap.

Leukoplakia

Leukoplakia, white patches in the mucous membrane resembling white enamal paint (Bloodgood), is a very common precancerous lesion of the mouth (Fig. 198). It represents a piling up of the outer layers of the epithelium and is almost invariably caused by the excessive use of tobacco. It may be smooth in the early stages, but in more severe cases it becomes very thick and rough with fissures and induration at the base.

Treatment. The application of any irritants to these lesions is contraindicated. Smoking should be prohibited and the lesions watched at regular intervals. If they become hard and fissured, they should be excised with the electrosurgical knife or actual cautery, and the tissue should be examined under the microscope. Otherwise, they should be left alone, they may disappear following the removal of the cause, or they may remain dormant and harmless.

It should be recognized that leukoplakia is a definite premalignant lesion, and when there is not a definite tendency to regression or when the patient cannot be observed frequently, excision is the safer treatment.

CARCINOMAS

Tongue and Mouth

Most carcinomas of the mouth arise from the pavement epithelium of the buccal cavity. They are called variously epithelioma or epidermoid carcinoma. They appear much more frequently in men than in women, and this is believed to be due largely to the frequency of smoking in males

Etiology. It is estimated that from 50 to 75 per cent of carcinomas of the tongue could be prevented by vigorous elimination of precancerous conditions. Leukoplakia is believed to account for 35 per cent of all buccal cancer.[15] Destruction of these areas is probably the most important single prophylactic measure against lingual malignancy. Papillomas, ulcers and fissures are other premalignant lesions of the tongue. These are usually overlooked or disregarded by the patient or the examiner who sees them at this stage. Nevertheless, vigorous early treatment may prevent subsequent development of cancer. Many of these lesions may be excised, either with a knife or an electric needle in the pre-

cancerous stages, and in most instances the operation may be performed under local anesthesia in the ambulatory patient.

Diagnosis. At times there is doubt as to the nature of the lesion which appears on the tongue or in the mouth. The diagnosis often can be made on simple inspection and palpation when it is borne in mind that most malignancies of buccal mucosa are characterized by a hard indurated ulcer. Sometimes the growth may be more papillary in character, and occasionally it appears as a hard nodular growth which involves the mucous membrane secondarily. Usually, a correct diagnosis can be made clinically, but at times it may be difficult to distinguish between carcinoma and a luetic lesion, either gumma or a sclerosing glossitis. Especially is this true if a positive history of syphilis or a positive Wassermann reaction is obtained. The important differential point is usually the single lesion of carcinoma, situated most often at the border of the tongue, as compared with the multiple lesions which may be at any site on the tongue in gumma. Furthermore, the carcinor tous ulcer is usually painful and ble easily, whereas the gumma is not p ticularly painful, nor does it bl readily.

Tuberculosis of the tongue is se occasionally, and this also must be tinguished from carcinoma. The berculous lesion appears almost variably in an individual who has d nite pulmonary tuberculosis. It n occur as a superficial or a fairly de ulcer, and it usually appears at tip of the tongue (Fig. 199). The l of induration surrounding the ul is a diagnostic point.

In making a diagnosis, the remo of biopsy specimens is perhaps most conservative method. This c be accomplished very frequently ambulatory patients. A topical ap cation of cocaine solution, 10 to per cent, is used; it is held in pl on a pledget of gauze from 1 to minutes. Excision biopsies, with knife, a biopsy punch or the lo electrode, may be made with this ty of anesthesia (Fig. 200). In removi tissues for biopsy examination, it m be remembered that the tissue at



Fig. 199. Tuberculosis of the tongue. (Trueblood, D. V.: West. J. Surg. 46:395-411)

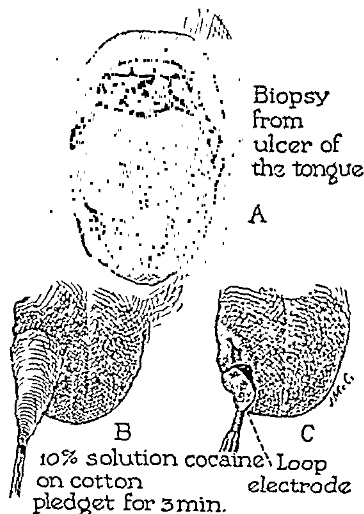


FIG. 200 Biopsy of an ulcer of the tongue following local application of 10 per cent cocaine solution. The cutting current with a loop electrode is an excellent method of removing such biopsies

edge of the ulcer gives the most characteristic appearance under the microscope. The necrotic fungating material at the base of the ulcer may be nothing but chronic granulation tissue or necrotic cells and of no help in making the diagnosis.

Treatment. In the treatment of carcinoma of the mouth, especially of the tongue, hospitalization is generally advised. However, in some instances, irradiation therapy, usually by implantation of radon seeds, may be carried out with the patient ambulatory throughout his period of treatment. The treatment of the actual carcinoma will not be discussed in this respect because of the wide variation of opinion which may be obtained on this subject. Suffice it to say that a combination of surgical and radiologic treatment is perhaps the best answer to the problem at present.

Lip and Buccal Mucosa

Almost all that has been said concerning carcinoma of the tongue may be repeated with regard to the lip and the buccal mucosa (Fig. 201) There is, however, a characteristic difference between these two tumors in that carcinoma of the tongue is a lesion that grows rapidly and is fatal, whereas carcinoma of the lip is a com-

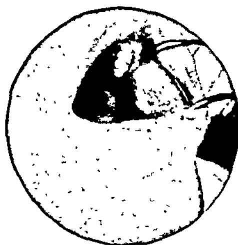




FIG. 201 (*Left*). Epidermoid carcinoma of the buccal mucosa. (Thoma, Kurt H., Internat. Abstr. Surg. *in* Surg., Gynec. & Obst. 67:522-545)
FIG. 202 (*Right*). Carcinoma of the lower lip. (Eugene P. Pendergrass)

paratively slow-growing ulcer with a fairly good prognosis if it is seen in the early stages. It appears almost invariably as an ulcer and most frequently in the lower lip (Fig. 202). Many believe that chronic irritation is a definite factor in its causation. The ulcer refuses to heal, and this is a diagnostic point in differentiating it from other ulcerative lesions of the lips. Any ulcer which persists and does not show progress in healing in a period of two weeks should be strongly suspected of being carcinoma.

Treatment. The treatment of carcinoma of the lip has progressed greatly with the advent of new methods of irradiation therapy. The use of radium, either locally or by implantation, and the application of roentgen rays to the areas of carcinomatous spread in the lymphatics of the neck have given excellent results in many cases. A combination of surgical excision and irradiation is used also in many clinics. No attempt will be made here to outline the therapy because of the rapid strides which are being made in this direction. It is enough to say that the radiologist and the surgeon should consult concerning the most effective method of handling each case.

HEMORRHAGE FOLLOWING TOOTH EXTRACTION

Etiology. Hemorrhage following tooth extraction is not a common complication, but it does occur and occasionally becomes a serious matter. It may be the result of trauma at the time of the extraction of the tooth, of postoperative infection in the tooth socket or of some inherent abnormalities in the composition of the blood which prevent its normal clotting or prolong the bleeding time. Many of the blood dyscrasias and deficiency diseases predispose to excessive oral bleeding. When confronted with a hemorrhage from a tooth socket, it is most important to determine whether the bleeding is coming from the bony socket or from the gums.

Treatment. All blood clots should be freed from the socket by syringing with warm water. This, in itself, may terminate the bleeding. If the bleed-

ing comes from the gums, this can usually be controlled by suturing the margins together across the orifice of the socket and thus making pressure against the alveolar walls. If the bleeding comes from the socket, pressure, and not the use of drugs or chemicals, should be employed. The socket is packed tightly with ½-in. plain or iodoform gauze with selvage edges. If oozing persists after a few minutes, further pressure is applied by placing a ball of slightly softened dental modeling compound over the gauze and having the patient bite down on it. This ball should be of such size that it will come in contact with the opposing gums or teeth before the jaws are entirely closed. It may be necessary to wire the teeth of both jaws together to maintain this added pressure. In any case, the gauze should be left in place for at least 18 hours The cavity may be packed with Oxycel gauze, which does not have to be removed If the gums and the alveolus have been so badly mutilated during the removal of a tooth that pressure packing is impossible, ligation of the main artery to the affected area is indicated. The blood should be examined following any considerable loss and proper corrective measures taken, according to the findings, as in hemorrhage from any other part of the body.

ULCERATIONS IN THE MOUTH

There are a great many forms and causes of ulcers in the mouth. They may be found anywhere on mucous membrane, gums, cheeks, palate, throat, lips and tongue. They may be single or multiple and involve large areas of tissue. We therefore speak of a discrete ulcer or of an ulcerative or gangrenous stomatitis. The subject is too large to consider in detail at this time, but certain generalities may be cited to guide the examiner. Broadly speaking, ulcers may be considered as of (1) local and (2) systemic origin.

Local Lesions

Almost invariably, local lesions are the result of some irritation in the mouth. Sharp and jagged teeth and roots, poorly fitting dentures with rough clasps and other irregularities, too vigorous use of a toothpick or a too stiff toothbrush, tobacco, spices, repeated biting of the cheek and so forth may all cause ulcerations. The treatment for these is essentially removal of the irritant.

Ulcers of Systemic Origin

Etiology. Ulcers of systemic origin may be very extensive, particularly those involving the gingivae, and they may become gangrenous. They include lesions which may occur in such blood dyscrasias as leukemia, anemia, the various leukopenias and purpura; in many of the metabolic and the deficiency diseases, as diabetes and scurvy; in fusospirillar infections (Vincent's disease and trench mouth); following the excessive use of such drugs as those in the sulfanilamide and the amidopyrine groups, some of the preparations of mercury and bismuth and the ingestion of certain radioactive substances; and in many of the exanthematous fevers and skin diseases. There is a small, very painful ulcer, usually to be found in the vestibular grooves and under the tongue, which is termed an aphtha. Its cause is undetermined, but this aphthous ulcer is probably trophic and often follows gastro-intestinal upsets and extreme fatigue. It can usually be cured

· a single application of a 10 per nt solution of silver nitrate. The ıysician should know, however, that is unwise to apply any irritating ugs to lesions in the mouth unless : is sure of his diagnosis. He is al-ays safe in prescribing a mouthwash ntaining a pinch of salt and a tea-ɔoonful of peroxide of hydrogen in glass half full of warm water.

Of great importance is the recogni-on and the differentiation of the spe-ific ulcers, those usually found on the ps, the alveolus or the tongue and ıose of syphilis, tuberculosis and arcinoma.

Diagnosis of Chancre. In syphilis, he chancre is a single nodule about he size of a dime, very hard at the ase, with a craterlike ulceration. It evelops in 10 to 14 days after expos-ıre and is painless. The submaxillary ymph nodes are involved early. Dark-ield examination will show the trepo-ıema. Mucous patches are found, hiefly on the cheeks, as dirty gray ıreas which bleed very easily if they are touched. They may rarely simu-late the appearance of the chancre without the induration when seen on the lips.

Diagnosis of Tuberculous Ulcer. The tuberculous ulcer is secondary to pulmonary tuberculosis. It may be single or multiple and has a dirty granular appearance with overhang-ing edges; there is no induration at the base, and both pain and lymphatic involvement are variable. A biopsy will show the characteristic lesion. A smear may reveal the presence of the tubercle bacillus.

Diagnosis of Epithelioma. The ul-cer of an epithelioma is most often single with irregular edges, is indu-rated at the base, gradually grows larger over a period of weeks and is usually painful. The lymph nodes are involved late. It is often associated with leukoplakia. A biopsy will show the characteristic picture under the microscope.

Treatment. Each lesion should re-ceive its own particular treatment.

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. 16 .

The Neck

INJURIES

Lacerations

The neck is relatively protected by its position; therefore, lacerations and contusions of this area are not common. Not infrequently, however, ambulance and receiving-ward surgeons are confronted with patients who have attempted suicide or who have received blows or wounds in this area in a fight.

Treatment. The probability of serious wounds in these patients is not great. In spite of the profuse hemorrhage which comes almost always from the superficially placed external jugular vein, it is seldom that the deep vessels are involved in the laceration, or cut. Such superficial wounds are comparatively easy to take care of by simple ligation of the severed vessels and primary suture. It is not even necessary for the patients to be admitted to the hospital when the lacerations are small In cases of deeper incisions or of blows, the complication which is most likely is an injury to the trachea or the larynx. This is associated with definite signs—the spitting of blood and often subcutaneous emphysema, dysphonia and so forth. It is wise to admit such patients to the hospital because of the danger of more serious complications and the necessity for close observation for a period of time.

Contusions

Contusions of the neck, as compared with contusions elsewhere in the body, are rare. They are caused by direct blows and most often involve the trapezius muscle. Swelling and tenderness, associated with pain on turning the head, are the usual symptoms. Discoloration is a late and, usually, minor symptom unless a superficial vein has been injured.

Treatment. The treatment of neck contusions follows the principles used elsewhere in the body. Pressure is best applied by tight adhesive strapping, often applied over sponge rubber. A shave of the chest and the back should precede the strapping, and an application of tincture of benzoin will often protect the skin against irritation and blistering.

It is somewhat difficult to accomplish immobilization in the neck, but the patient's discomfort on rotation of the head will enforce his co-operation in this regard. A sling for the arm may be useful for a few days. Dry heat and, after 4 or 5 days, diathermy and massage are of value in hastening absorption of hemorrhage and exudate.

Sprains and Strains

Etiology and Symptoms. The most common injury of the neck is a sprain of the cervical ligament or a strain of the muscles. This may occur from a fall or from a twist obtained in contact games such as football and wrestling. The symptoms are stiffness and tenderness of the neck and pain on movement, especially movements against resistance. Often these symp-

toms increase gradually during the first 24 hours after injury. Roentgen examination should be made to exclude the possibility of a fracture of the cervical vertebrae

Treatment. The treatment of this type of injury is the same as that used for similar injuries elsewhere in the body It is difficult to obtain rest of the part. However, hot local applications in the form of hot towels or an electric pad, or heat applied by diathermy, may be used. Massage following the application of heat is also helpful. More rapid results are often obtained by the injection of the painful area with 1 per cent procaine solution. Usually about 10 cc. is used, and it may be necessary to repeat the injection in 24 to 48 hours In making the injection, the needle must be inserted with due regard for the important anatomic structures of the neck.

Brachial Plexus "Wrench"

Etiology. In severe injuries of the neck, especially in those in which the shoulder is driven down and away from it, the brachial plexus may have been injured by a sudden pull upon its roots.

Symptoms. The symptoms of brachial plexus "wrench" are extreme tenderness and pain over the entire shoulder and often down the arm. The muscles of the shoulder region, especially the trapezius, are frequently in painful spasm. The most marked tenderness is along the sides of the neck. The pain becomes worse on bending the head to the opposite side and is relieved somewhat by bending it toward the site of injury. Roentgen examination should be made to rule out lesions of the vertebrae, the shoulder and the acromioclavicular joints.

Treatment. In the treatment of brachial plexus injuries, it is imperative to relieve the shoulder of the weight of the arm. This may be done by placing the arm in a triangular sling supported by the uninjured shoulder or in an abduction cast or splint. This is especially necessary if muscular paralyses appear in the arm or the shoulder. In most cases of brachial plexus injury, the prognosis for eventual recovery is good if adequate early treatment is given. In a few cases, infiltration of the scalenus anticus with procaine has produced dramatic relief of pain.

INFECTIONS

Furuncles

Etiology. Furuncular infections are very common in the neck, especially in the hairy portions at the sides and the back. It is probable that the rubbing of shirt and coat collars is an exciting factor, especially in men. The author believes that barber's clippers are also a factor in the furuncles seen in men after haircuts. The infecting organism is the *Staphylococcus aureus,* and experience seems to point to an individual susceptibility to this infection.

Treatment. The furuncles begin with a sense of itching and slight burning, and may immediately regress without further symptoms and without treatment. More commonly, they progress to a raised, reddened, tender mound of induration, which seems to be pressed upon with every movement of the head. At this stage, it is occasionally possible to abort the infection by the use of antibiotics. Penicillin usually is chosen and, as a rule, controls the infection at once. If resistant organisms are encountered,

as determined by sensitivity tests, other antibiotics may be used—aureomycin, terramycin or erythromycin.

Boils

Frequently, an infection which begins as a small and innocent-looking furuncle will progress and form a large area of infection commonly described by the laity as a "boil." The infected area becomes larger and more painful as the wall of inflammatory induration advances in the dense tissues of the neck. The tenseness of the lesion makes every movement torture.

Treatment. Intensive antibiotic therapy—penicillin or erythromycin—usually will result in rapid subsidence of the inflammation and control of the infection.

When the pain is intolerable or when the induration appears to be spreading, a crucial incision to provide drainage is necessary (Fig. 201). This is best made under a short general anesthesia, Vinethene being ideal. Hot moist dressings of saline or boric acid solutions should be applied until the slough liquefies and separates. A packing of plain or iodoform gauze may be used to control oozing at the time of incision, but, after its removal on the second or the third day, none need be reinserted. The hot wet dressings are discontinued when the slough has been discharged, and a simple dry dressing is applied.

Carbuncles

Course of Infection. In the dense tissues of the back of the neck, the furuncular infection often progresses laterally and deeply instead of to the skin surface. The necrosing action of the staphylococcic toxin attacks especially the fatty tissues lying in the interstices between the fibrous septa that extend from the deep fascia to the skin. The fibrous tissue then succumbs to the necrotoxin, so that eventually a large area of subcutaneous necrosis forms that involves not only the subcutaneous fatty tissue and its fibrous septa but also the dense underlying fascia. Numerous sites of pointing appear on the skin in the center of an extending area of tense induration. Not infrequently, the infection extends from one side of the neck to the other.

Symptoms. Besides the local symptoms of intense throbbing pain and excruciating tenderness, there often may be enough absorption of toxic products from the infection to produce fever and leukocytosis. When large carbuncles appear in patients of middle age or beyond, their association with diabetes must be considered. Determinations of blood and urine sugar should be made.

Treatment. In the care of patients with carbuncles, hospitalization is often preferable, and, in those who are diabetic, it is sometimes imperative. However, many patients with carbuncle of the neck can be kept ambulatory during treatment. This is especially the case with the use of penicillin as described above.

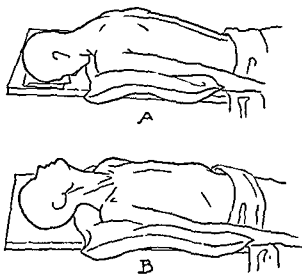
The treatment of carbuncles which appears to give the best results in relief of pain and rapidity of healing is radical incision and drainage. The operation is performed under general anesthesia—Vinethene or nitrous oxide and oxygen—or intravenous anesthesia, except in late carbuncles, where the drainage openings may be connected by cutting the intervening intact skin with scissors without anesthesia. In small carbuncles, a crucial incision is best (Fig. 204). This should

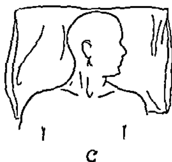
reach the full depths of the necrotic tissue, and should extend throughout the length of the carbuncle in each direction. Each quarter segment is grasped by an Allis forceps and undercut to the full extent of the necrotic tissue. The period of healing is shortened if the corner of each segment is cut away and as much necrotic tissue as possible is also removed. This is not sacrificing any viable tissue, and recovery is hastened by excising tissue which would otherwise have to undergo liquefaction necrosis and be discharged as slough or pus. Bleeding is sometimes rather brisk, but ligations are never necessary, as hemorrhage can be controlled by a snug packing of plain or iodoform gauze and a pressure bandage.

In larger carbuncles, the central core comprising all the draining sinuses should be boldly excised down to the necrotic fascia. Radial incisions are then made through the remaining indurated tissue to the limit of necrosis in all directions. These multiple flaps are then caught with Allis forceps and each is undercut. With scissors or a knife, all frankly necrotic tissue is excised, especially the dense fascia at the base of the carbuncle. The wound is then held open by traction with Allis forceps and is entirely covered with wide-mesh paraffin gauze. Within this dam, fluffed gauze is snugly packed in sufficient amount to give pressure. In spite of brisk bleeding, no ligations are necessary if an adequate pressure dressing is applied.

The most satisfactory dressing is a figure-of-eight bandage of the head and the neck (Fig. 68). After the bandage has been applied, the patient is placed on his back for a time with a pillow arranged to give pressure on the wound. The patient may be allowed to go home after about an hour of rest, but should be given 5 or 6

Fig. 205. Position of patient for operations on the neck. It is rare that an operation on the neck can be performed conveniently with the patient lying on his side. (A) For operations on the back of the neck, the patient lies in the prone position, with a pillow under the chest and a small support under the forehead. (B) For operations on the front of the neck, the chest is raised with head and neck extended. (C) For operations on the side of the neck, the patient lies in the supine position with the head turned away from the site of the operation.





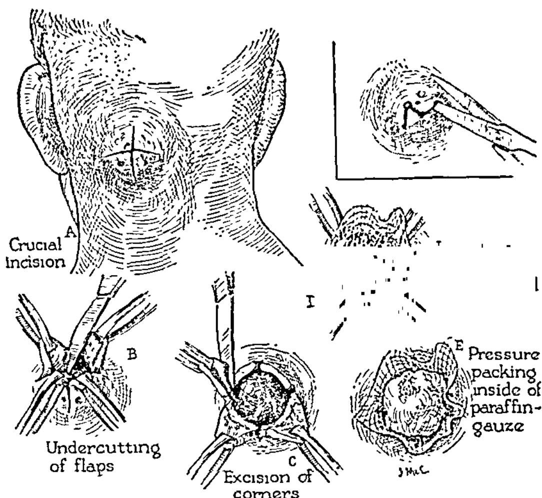


FIG 204. Steps in the incision of a boil or a carbuncle of the neck. (A) A crucial incision is made in the most prominent portion of the induration, and the corners of the incision are caught with Allis clamps (B). Each flap is undercut as far as the necrosis extends. The corners of the flaps are excised (C) because these always become necrotic. (D) The base of the wound is covered with a paraffin-gauze shell and (E) a pressure packing is inserted inside the paraffin gauze. Inset shows conservative method of opening carbuncle when necrosis has progressed to the point at which there are numerous small cutaneous draining points These may be joined by cutting with scissors without anesthesia.

tablets of morphine sulfate, 1/6 gr., to be taken every third hour by mouth as needed for pain. The dressing should be inspected before he leaves and, if bloody, the outside dressings may be changed and a new bandage applied.

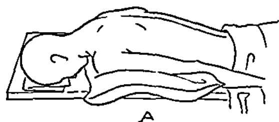
Nothing is done to the wound for the first 12 to 24 hours; thereafter hot saline or boric acid solution is used to moisten the dressing 3 or 4 times daily. The dressing is not changed until the third day, when the amount of gauze within the paraffin dam is re-

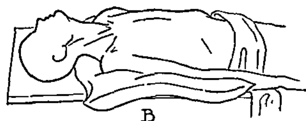
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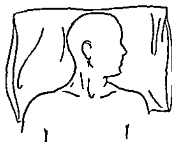
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used to advantage. When the flaps have grown in place, the wound will have decreased much in size, but frequently a few pinch grafts may be employed to hasten epithelization and reduce scarring (Fig. 205).

Ludwig's Angina

Ludwig's angina is an acute infection involving the tissues of the submaxillary and the sublingual spaces. It is believed by many, especially Grodinsky,[11,12] that the infection arises in the floor of the mouth and extends by contiguity along the fascial planes to involve these spaces. The infection produces a dense cellulitis of the floor of the mouth, usually bilateral, which is tender but rarely fluctuant. The skin usually does not show any inflammatory reaction except edema. The most marked signs appear in the floor of the mouth, which is raised, edematous and brawny hard, with ulcerations. The tongue is swollen and pushed upward and often forward, protruding between the teeth in advanced cases. The patient experiences considerable pain and great difficulty in attempting to open the mouth. Swallowing and speaking are difficult, and respiratory embarrassment, which may become fatal, is a frequent and an almost constant symptom. Temperature, pulse and respiration vary; usually they are somewhat elevated and at times markedly so. In the majority of cases, the infection arises from an infected tooth, usually a lower molar, although it may also extend downward from a wound in the floor of the mouth.

When the infection is in the sublingual area, it is between the tongue and the mylohyoid muscle, which extends as a diaphragm from the inner surface of the mandible to the hyoid. It may be confined to this space, or it may extend round the posterior border of this muscle along the submaxillary gland to the submaxillary space (Fig. 183). This space is sharply limited by the attachment of the deep cervical fascia from the ramus of the jaw to the anterior and the posterior bellies of the digastric muscle. When the infection appears in this tightly confined space, it produces marked edema and swelling. The tongue is swollen and pushed upward, and in advanced cases it may almost fill the oral cavity due to sublingual edema. The infecting organism is often the streptococcus. Pus is found late in these cases; therefore, fluctuation is not a prominent symptom.

Usually Ludwig's angina cannot be treated in an ambulatory patient because a wide incision of the floor of the mouth, especially through the mylohyoid muscle, is necessary to produce adequate drainage. Nevertheless, it should be described in this connection because of the fact that it must be distinguished from other lesions in this area, especially cellulitis and lymphadenitis of the sublingual and the submaxillary tissues. The absence of local inflammatory signs and the marked involvement of the tissues of the floor of the mouth help in the differentiation of the typical Ludwig's infection and the more superficial infections of the submaxillary area.

Cervical Adenitis

Anatomy. The cervical nodes are usually described as being divided into superficial and deep groups. As a matter of fact, this division is largely an anatomic one and is based on the fact that the superficial nodes lie on top of the superficial fascia and the deep nodes lie below it. However, the



FIG. 205 Skin grafts applied to the granulating area left after incision of a large carbuncle. The grafts were removed from the thigh under local anesthesia and placed upon the area: practically all of them took. This patient was ambulatory throughout his entire treatment.

duced or removed. The paraffin mesh is allowed to remain until it comes away itself. No new packing is inserted into the cavity of the carbuncle The problem then is one of removing the necrotic tissue. No substitute has been found for mechanical measures, that is, scissors and forceps, and wound irrigation.

Healing does not begin until the slough is removed, and sloughing fascia liquefies very slowly; hence the advantage of mechanical excision in clearing the wound of necrotic tissue.

Enzyme débridement of a slough and necrotic tissue is now possible since commercial preparations have become available for topical application. Crystalline trypsin—Tryptar—is dispensed as a lyophilized powder in a rubber stoppered bottle. Its tryptic activity is exerted best at a pH of 5 to 8. To ensure a reaction in this range, the wound may be irrigated with a buffered phosphate solution supplied as a diluent with the crystalline powder. Probably the most effective use of Tryptar is obtained by the application of the trypsin powder to the necrotic area with a spatula or a powder blower. The enzyme must be reapplied every 15 to 30 minutes, because it is inactivated by trypsin inhibitors and washed away by an outpouring of serum.

Tryptar may also be used as a wet dressing. The solution is prepared by adding the buffered phosphate solution to the bottle of crystalline trypsin with a sterile needle and syringe. The Tryptar solution is then used to moisten sterile gauze sponges which are applied to the necrotic wound. The solution must be reapplied every 3 hours, because approximately 75 per cent of the enzymic activity is lost after this period.

Except for a slight smarting after the powder is applied to an open wound, trypsin applied locally has no untoward effects. It does not injure viable tissue, and it is effective in rapidly liquefying necrotic tissue.

Streptokinase-streptodornase (Varidase) is another enzyme preparation used for topical application to necrotic wounds. The Varidase is prepared by dissolving the enzyme powder in 5 ml. of sterile distilled water, a sterile syringe and needle being used The solution is added to a jar of carboxymethylcellulose jelly (15 cc.) and thoroughly mixed. The Varidase jelly is then applied to the necrotic wound. The unused portion of the jelly retains its enzymatic effectiveness for about a week if kept in a refrigerator. Varidase jelly is especially useful in wounds which contain necrotic tissue and clot.

When the wound is filled with clean granulations, the flaps may be replaced, adhesive strapping often being

scessed tooth, infected tonsils, an infected scalp and similar complications (Fig. 206).

The infection of a lymph node is usually characterized by a swelling of the node and, frequently, of several of the adjacent nodes. This swelling may be somewhat slow in appearance and may be characterized only by tenderness. It may arise some considerable time after the original infection has subsided. On the other hand, the infection may develop rather rapidly with an acute swelling, extreme tenderness and considerable edema and redness of the overlying skin and subcutaneous tissues. This latter type of infection is more likely to occur in children, in whom an acute suppurative lymphadenitis is a relatively common infection Often the deep nodes underneath the sternocleidomastoid muscle are involved. Frequently, however, the submaxillary glands are also involved, and in children with scalp infection it is not uncommon to see the swelling appear behind the ear in the occipital or the postauricular groups. The infection is usually staphylococcic, but it may be streptococcic, depending on the type of primary infection. In the streptococcic type of infection, there are marked constitutional symptoms and almost invariably a rather high fever.

Treatment. Conservatism is the rule in the treatment of acute cervical adenitis. Usually, intensive antibiotic therapy—penicillin, Aureomycin, Terramycin, erythromycin—can be counted on to abort an early infection. When the inflammation has progressed to fluctuation, incision and drainage are required. During this period one must not neglect treatment of the primary focus in the mouth, the pharynx, the ear or the scalp.

Acute Suppurative Cervical Adenitis

Not infrequently, children are brought to a doctor's office or a surgical outpatient department after the infection of the cervical glands has gone on to suppuration. This progress from acute adenitis to cervical abscess usually takes a period of several days or even weeks.

Diagnosis and Treatment. When the superficial nodes are involved, the diagnosis of the lesion is evident and the treatment is simple (Figs. 207 and 208). The process appears as a red, tender, fluctuant area, usually on the side of the neck or underneath the mandible. The pus appears to be just under the skin, and, if an incision is made in the longest diameter of the abscess, this is found to be so. As a rule, adequate incision and drainage of the abscess necessitate a general anesthetic in children; Vinethene is excellent for this purpose. In adults, a line infiltration with procaine or phenol is usually adequate. The incision is made through the softest portion of the abscess presenting on the skin surface; this is usually the site at which the abscess is closest to the surface. When it has been incised, the edges of the wound are grasped with Allis forceps, or small rake retractors are introduced, and the abscess is explored with the finger or a curved hemostat. After its extent has been determined, the incision is enlarged throughout the entire length of the abscess cavity. The wound is packed with petrolatum or iodoform gauze and a firm dressing is applied. The packing may be removed in 2 or 3 days, and, if the incision has been adequately made, the wound edges will gape enough to permit adequate drainage. Simple surface dressings are



FIG. 206 (*Left*). Acute suppurative cervical adenitis in 7-month-old baby following tonsillar infection

FIG. 207 (*Center*). Acute suppurative cervical adenitis 9 days after extraction of an infected tooth.

FIG. 208 (*Right*). Suppurative adenitis of 4 weeks' duration following a sore throat

numerous communications between the superficial and the deep groups make this division impractical physiologically and pathologically. Frequently, an infection extends from one group to the other, usually from the superficial to the deep, so that infection in one group does not necessarily mean that the other group will not be involved.

The superficial nodes are divided into 3 chief groups: (1) a submental group, which lies below the symphysis of the mandible; (2) a submaxillary group, which lies beneath the ramus of the jaw, and (3) a posterior group, which lies below the angle of the jaw and behind the ear. This division is important for practical purposes because, as a rule, the submental group drains lymph from the area of the lower lip and the mouth, especially toward the anterior portion. The submaxillary group drains the floor of the mouth, the lips, especially the upper lip, the sinuses and the face. The posterior group drains the ear and the scalp.

The deep cervical nodes lie mostly underneath the sternocleidomastoid muscle, and their general direction is arranged along the course of the great vessels. Those most frequently involved in the cervical region are the superior deep cervical nodes which drain the region of the tonsils and the pharynx.

A knowledge of these anatomic points is of considerable importance in helping the surgeon locate the primary focus of infection, which must be investigated in an intelligent treatment of cervical adenitis.

Acute Cervical Adenitis

Etiology and Symptoms. An acute inflammation of the cervical lymph glands is always the result of a primary infection somewhere in the area which drains lymph into these nodes. It is not always possible to find the primary source of infection, but, when possible, treatment should be directed not only to the infection of the lymph node itself but also to the primary source of infection, such as an ab-




Fig. 211. Tuberculous adenitis in a child, excised under local anesthesia. (*Left*) Large mass of tuberculous nodes. (*Right*) Result 1 month later. Patient ambulatory throughout.

form or plain gauze packing may be introduced round it for the first 2 or 3 days. The purpose of this packing is to control bleeding and to separate the edges of the wound until such time as inflammatory induration holds the wound open. After removal of the packing, the tubes are allowed to remain in place, but packing is not reinserted The dressings should be moistened at intervals of 3 or 4 hours with a boric acid or saline solution to prevent the drainage material from drying and plugging the drainage tract. As soon as the slough has separated from the abscess cavity, the double-barreled drainage tube may be removed and the wound allowed to close with the application of simple sterile dressings.

The application of a dressing which will provide pressure and also stay in place in ambulatory patients is a difficulty frequently experienced in treating cervical abscesses. It should be applied in sufficient amount to permit pressure on the wound by the bandage and to form a good compress for hot moist dressings. The bandage that we have used successfully is illustrated in Fig. 209. It begins at the back of the neck, is first applied as a circular bandage round the neck for 1 or 2 turns, then is brought under the chin, upward over the head, downward round the occiput to the opposite side of the neck, forward underneath the chin and upward, the bandage being crossed from the opposite side in the mid-line of the scalp. It is then continued round the opposite side of the occiput forward round the neck and continued in repeated turns as before. The bandage is secured by tightening the bands on either side of the head and over the mid-line of the scalp with a simple tie of bandage gauze (Fig. 67).

Tuberculosis of the Cervical Lymph Nodes

Etiology. Tuberculous infection of the cervical lymph nodes is seen most





FIG. 209 (*Left*). Bandage for lesions of the front and the sides of the neck.
FIG. 210 (*Right*). Unilateral tuberculous cervical adenitis with one discrete node involved

all that are necessary until healing occurs.

When the deep cervical nodes are involved, the lesion is less easily diagnosed. Because of their deep situation, fluctuation is demonstrated with considerable difficulty, although experienced fingers are often able to determine it when inexperienced ones miss this diagnostic point. One may conclude, however, that if the enlargement of the nodes has persisted for a period of from 10 days to 2 weeks following the subsidence of an acute infection in the mouth or the pharynx, the probability is that suppuration has taken place in the infected gland and incision and drainage are indicated. In the drainage of deep nodes, as in the drainage of superficial glands, a general anesthetic is usually indicated in children, but local infiltration may be employed in adults. The incision is made through the skin and the platysma, and a blunt hemostat is introduced into the most prominent portion of the enlarged lymph nodes. If the proper site has been selected, pus will immediately follow the withdrawal of the hemostat. Often the pus is slight in amount, but it can easily be distinguished in the bloody discharge from the wound. The instrument should be reinserted into the opening when pus is found and withdrawn with the blades open (Fig. 85), thus bluntly enlarging the abscess opening without much danger of wounding adjacent structures.

In deep cervical abscesses, it is sometimes impossible or inadvisable to enlarge the wound so as to lay open the entire abscess cavity because of the danger of injuring important near-by structures. In such cases, the insertion of a double-barreled rubber tube (Fig. 86) into the abscess cavity usually provides adequate drainage, and this tube may remain until the suppuration has clearly subsided and all of the slough has disappeared. When the tube has been inserted into the cavity, iodo-

Treatment.[5] The treatment of cervical tuberculous adenitis may be surgical or conservative, or it may be by irradiation. Perhaps the best results are obtained by a combination of these methods. In those patients who are seen early and before cold abscesses have developed, excision of the involved nodes is probably the most satisfactory treatment. As a rule, this operation can be performed under local anesthesia, even in children, and the nodes involved removed by careful dissection. The remaining cavities are obliterated by fine catgut sutures, skin closure is performed without drainage and a firm compression dressing is applied.

In addition to the surgical removal of the nodes, the presence of an active tuberculous infection must be borne in mind, and these patients should be placed on appropriate antituberculosis therapy. This may be carried out in ambulatory patients, and the following routine is recommended:

Streptomycin 1 Gm. 3 times a week, combined with either P. A. S. (para-amino salicylic acid) 12 Gm. daily or Isoniazid 300 mg daily. Vitamin therapy, especially A and C, is also given. This treatment should be continued for a full year.

Prognosis. Statistical studies made of patients with cervical lymphadenitis of tuberculous origin show that its occurrence in children and in young adolescents does not subject them to a greater risk than usual of developing pulmonary tuberculosis. It is even believed that lymph-node tuberculosis occurring early in life serves actually to immunize the individual against the more lethal forms of the disease. Stanton and Richard,[20] in an investigation of 115 cases of lymph-node tuberculosis, did not find that pulmonary tuberculosis had developed in a single patient in whom the adenitis appeared in childhood or in adolescence.

Cold Abscesses

Treatment. In patients presenting themselves in the late stages of the disease with the development of a cold abscess in the neck, an attempt to remove the involved nodes is somewhat difficult. Aspiration of the abscess by inserting a needle through normal adjacent tissue has been advocated. Repeated aspirations are often necessary. Some surgeons have made a small incision through the most prominent portion of the abscess, followed by curettage of the tuberculous mass and subsequent primary suture of the wound. The reason for primary suture is to avoid, if possible, the entrance of secondary invaders into the area of tuberculous caseation necrosis. This method is worth a trial. It is useful in permitting a subsidence of the cavity and hastening the time when excision of the involved glands may be performed.

Tuberculous Fistulas

Tuberculous fistulas resulting from rupture of cold abscesses are not uncommon, although their appearance is much less frequent now than formerly. The sinuses appear as small openings which drain a thin fluid containing flakes of caseous material. The sinuses, at first tuberculous, always become secondarily infected, which accounts perhaps for the continued drainage and for the failure of the sinuses to close.

Treatment. In the treatment of tuberculous sinuses, an attempt is made to remove the tuberculous lymphatic tissue. Often a calcified area of

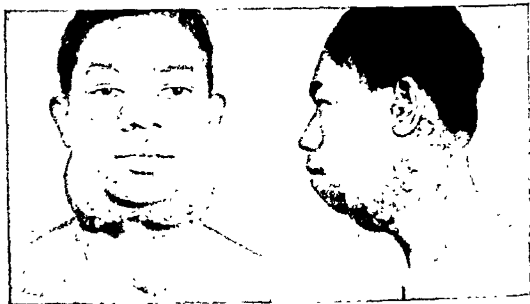


Fig. 212 Advanced tuberculous adenitis of neck with multiple draining sinuses.

often in children and in adolescents It may, however, appear at any age, and in our experience is much more common in Negro patients. In the majority of cases, the infection is believed to be of the bovine type. The relative infrequency of the disease now as compared with the former high incidence is thought to be the result of more careful inspection and testing of milk herds and pasteurization of milk. Most authorities agree that it occurs first as an infection of the tonsillar or other lymphatic tissues of the nasopharynx, with secondary extension into the lymph nodes of the neck. Reid and Wilkinson[18] reported on 119 cases, in 85 of which there were signs or histories of tonsillar disease.

Course and Diagnosis. Usually the infection begins as a discrete enlargement of the lymph nodes of the neck, generally the superior cervical, the upper deep cervical or the middle superior deep cervical nodes. The presence of a bilateral infection is frequent, although not invariable. This finding has often been cited and used as a diagnostic point in differentiating tuberculous enlargements of the nodes of the neck from other enlargements, such as Hodgkin's disease and lymphosarcoma. In our experience, unilateral involvement has not been uncommon (Fig. 210). The discrete enlargement of numerous nodes gradually progresses and involves other adjacent nodes (Fig. 211), and, as the process continues, caseation necrosis may appear with the production of cold abscesses (Fig. 212). As a rule, this stage of the disease is not reached for many months, even years, and most patients seek treatment nowadays long before the cold-abscess stage is reached.

In the diagnosis of tuberculous cervical adenitis, the discrete enlargement of numerous nodes is an important finding. The absence of pain and tenderness, heat and other signs of acute inflammation is characteristic and helps to rule out the possibility of an acute pyogenic adenitis.

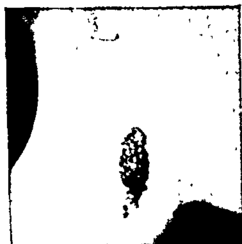


FIG. 215 Pigmented mole of the neck in a young boy, excised under local anesthesia. This did not prove to be malignant.

tumors cause no symptoms except disfigurement, and it is usually for this reason that patients seek operation.

Treatment. The removal of the anterior and the lateral lesions is usually performed under local anesthesia. If the tissues are kept on tension, the tumors may be shelled out without difficulty, and closure of the resulting wound is performed by a deep layer of obliterating sutures with mattress sutures in the skin. If a pressure bandage is applied, usually a drain is not necessary in the wound.

The operation for the removal of lipomas of the back of the neck is not as simple as that for removal of these tumors elsewhere in the body. Here they are traversed by multiple fibrous tissue septa, so that their removal necessitates a shelling out of numerous fatty projections from the fibrous tissue spaces of the neck. This type of dissection must be sharp; therefore, the operation is frequently attended with considerable bleeding. After removal of the tumor mass, the cavity left is obliterated with buried sutures and the skin is approximated with mattress sutures of wire, silk or cotton. A firm pressure bandage must be applied; the most satisfactory one for this purpose is a figure-of-eight bandage of the head and the neck (Fig. 68).

MOLES

The neck is a common site for moles and melanomas. Prophylactic therapy by early excision is indicated, especially for moles in areas which are constantly irritated by rubbing of the collar (Fig. 215).





FIG. 216. Mid-line aberrant thyroid adenoma.

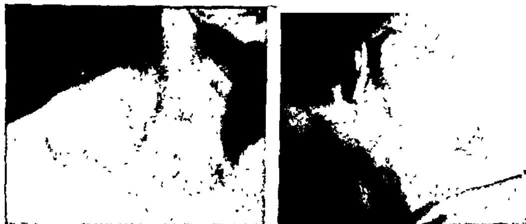


FIG. 213. (*Left*) Lipoma of the neck. Such tumors in this location always are soft and give almost a sense of fluctuation. (*Right*) Fibrolipoma of the side of the neck. Such tumors are firm, fixed and very definitely circumscribed.



FIG. 214 Fibrolipomas of the back of the neck. The small tumor is typical: it is hard and not movable in the tissues because it is traversed by numerous fibrous-tissue trabeculations The large tumor is diagnosed easily and is removed more easily.

a caseous node may act as a foreign body. The sinus tract should be explored, and the tuberculous node curetted to remove as much as possible of the caseous and calcified material. An iodoform drain inserted into the sinus tract may then promote eventual healing. If this sort of treatment is not successful, a formal excision of the sinus tract and of the involved caseous tuberculous glands is worth while.

BENIGN TUMORS

LIPOMAS

Diagnosis. The neck is a common site for the development of lipomas On the anterior and the lateral surfaces, they are usually soft, movable tumors with definite lines of demarcation (Fig. 213). Their softness is often confusing, and they are sometimes mistaken for fluctuant masses.

Less easily recognized and less easily operated upon are the lipomas which occur in the back of the neck (Fig. 214). This is a relatively common site for these lesions. They appear as large, rather firm, more or less thick swellings. There is no definite edge to the tumor, and as a rule they have grown slowly over a period of years. The



FIG. 218. Examples of epithelial inclusion (dermoid) cysts in the neck. All these cysts were excised under local anesthesia in ambulatory patients.

tion of cysts. The walls of such cysts are true skin with its appendages, sweat glands, hair follicles and sebaceous glands. They are relatively rare in occurrence and arise most commonly in the anterior portion of the neck, below the level of the isthmus of the thyroid gland. The cysts are slow in growth and painless, and the patients present themselves because of the disfiguring mass (Fig. 218). They are easily removed and do not tend to recur following complete removal. The operation may be performed under local infiltration or local block anesthesia.

THYROGLOSSAL CYSTS AND FISTULAS

Etiology. The embryologic development of the median portion of the thyroid gland accounts for the appearance of cysts and fistulas in the midline of the neck. The median anlage of the thyroid is formed at the base of the tongue. It descends rapidly through the tongue and the neck tis-



FIG. 219. Thyroglossal cyst. This patient was treated by aspiration and injection of Carnoy's solution The cyst disappeared and had not recurred a year later.

Aberrant Thyroid Adenomas

Etiology. In the formation of the thyroid there are opportunities for bits of thyroid tissue to be separated from the main portion of the gland. These remain as simple rests of thyroid tissue. Very frequently, they begin to grow and form a small aberrant thyroid gland. They appear most often in the mid-line (Fig. 216) and along the lateral edge of the sternocleidomastoid in the base of the neck. They are firm, rounded masses with no attachment to the overlying skin but are attached deeply.

Treatment and Diagnosis. Their removal is a relatively simple matter and can be performed under local anesthesia. The difficulty lies in making the diagnosis. The mesial thyroid adenomas occurring in the mid-line must be differentiated from thyroglossal cysts and from mid-line lymph-node enlargements. The diagnosis from thyroglossal cyst is usually easy, in that the thyroglossal duct enlargement is cystic, whereas these tumors are solid masses. The differentiation between thyroid adenomas and mid-line lymph-node enlargements is more difficult, and is made on the basis of the subcutaneous position of the lymph nodes and the deeper position, underneath the sternohyoid muscles, of the thyroid adenoma. It is difficult to distinguish the lateral thyroid adenomas from branchial cysts, but this is not important because in most cases, the treatment for both lesions is operative.

CYSTS AND FISTULAS

Sebaceous Cysts

Sebaceous cysts are not uncommon in the skin of both the anterior and the posterior portions of the neck. They may easily be removed under local anesthesia (Fig. 105).

Pseudocysts

Pseudocysts are often formed in the neck due to ingrowing hairs. These hairs, which have been shaved or cut off close to the skin surface or even below it, tend to turn inward underneath the surface of the skin, and thus form a sort of foreign-body cyst. Usually, these become infected, and eventually the hair is removed as a long curled-up fiber. The hair may become encysted, and in such cases a *tumor* mass may be palpated. The entire mass may be excised and sutured primarily (Fig. 217).

Epithelial Inclusion (Dermoid) Cysts

The invagination of epidermal tissue in the embryo often leaves epithelial tissue beneath the surface of the skin. This tissue may lie dormant for years and then suddenly begin to show signs of growth with the produc-



Fig. 217. Pseudocyst due to ingrown hair.

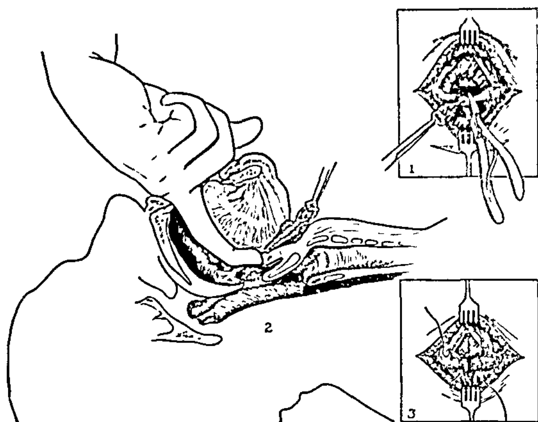


FIG. 221. Excision of thyroglossal sinus (Sistrunk). (1) Method of dissecting the sinus tract down to the hyoid bone and excising the mesial portion of the hyoid bone. (2) Excision of the tract above the hyoid to the base of the tongue. (3) Method of uniting the hyoid in the mid-line after excising the tract.

If the thyroglossal fistula has been of some duration, it is usually possible to trace the tract to the hyoid bone as a firm tubular structure in the midline of the neck.

Treatment. The cure of thyroglossal cysts and sinuses depends upon the removal of all the epithelial tissue. This requires a dissection and excision of the cyst or the sinus, extending upward through or round the hyoid bone to the base of the tongue The operation may be performed under general or local anesthesia in ambulatory patients. The dissection of the superficial portion of the cyst or the sinus is relatively easy, and is made through a transverse incision, 5 or 6 cm. long, at the level of the cricoid cartilage.

After separation of the skin and the platysma, the sinus is traced along its path in the median raphe between the sternohyoid muscles up to the hyoid bone. Experience has shown that removing only the part of the tract lying below the hyoid bone almost invariably results in a recurrence of the cyst or the sinus, and that a complete operation must entail the removal of the mid-portion of the hyoid bone and the portion of the tract extending to the base of the tongue. Therefore, with adequate sharp retraction, the hyoid bone is exposed and about half an inch of its mid-portion is excised. With the finger in the mouth at the position of the foramen cecum, a tubular portion of the muscles of the

sues in the early portion of fetal life, and reaches its location anterior to the trachea in the mid-line. There it joins the 2 lateral lobes of the thyroid gland. There may be a distribution of some thyroid cells along the line of descent of this anlage. These have been given the name of the thyroglossal tract. Many believe that in the descent of the thyroid anlage, some of the oral epithelium from the base of the tongue is dragged down with it. This misplaced epithelium may be of the stratified or of the ciliated type, and secretion from it may give rise to the formation of cysts (Fig. 219). If the cysts are opened or rupture spontaneously, fistulas are formed. It is believed that the only evidence of abnormal development of cells from the thyroid gland itself is the formation of smooth, rounded masses of thyroid tissue, aberrant thyroid adenomas. These also appear in the mid-line of the neck, but they rarely become cystic.

Diagnosis and Symptoms.[2] The displaced oral epithelium may produce cysts at any age, more often perhaps in childhood than in adult life. They appear more in females than in males, about 2 to 1. The clinical features are quite well known. A swelling appears in the mid-line of the neck, usually between the hyoid bone and the cricoid cartilage, though it may appear anywhere in the front of the neck from the hyoid bone down to the sternum. Very often the patient presents himself for treatment after an incision has been made in this swelling, with the result that there is a sinus, or dimple, surrounded by considerable fibrous tissue (Fig. 220). This cyst or sinus opening rises on swallowing, due to the attachment to the base of the tongue. This is one of the diagnostic points in differentiating this type of swelling from other mid-line swellings in the neck. Usually, the cysts are painless and definite fluctuation may be obtained. Secondary infection occurs occasionally; in this case all the signs of inflammation are present, making the diagnosis somewhat more difficult. When a sinus is present, there is a constant discharge of a glairy, stringy, mucuslike material which causes the patient considerable inconvenience because of soiling. The sinus tract may alternately close and open, closing as the scar tissue at the orifice of the tract contracts and opening again due to tension in the cyst.



Fig. 220. (*Left*) Thyroglossal sinus following incision of an infected thyroglossal cyst. (*Right*) Chronic sinus with deposit of scar tissue following numerous excisions of an infected thyroglossal cyst.

Fig. 222. Lateral cervical cysts of the neck excised under local anesthesia in ambulatory patients.



any communication with the skin or the pharynx, may appear in the subcutaneous and the deeper tissues and communicate with the skin, or may lead from the skin through an epithelial-lined tract to the pharynx.

The cysts contain the products of epithelial metabolism, and, when there is an external opening, the discharge of these products causes an annoying constant drainage upon the skin surface. The epithelium lining the cyst may vary from the stratified squamous to the columnar type. The cysts at times become infected, often following an acute upper respiratory infection. In 1 case in the author's experience, infection of the cyst followed the removal of a number of infected teeth.

Diagnosis and Symptoms.[16,17] These cysts may appear at almost any age. In a series of 89 cases reported by Gaston,[9] the youngest was 15 years of age and the oldest 65. In most cases, the patients present themselves for treatment because of the appearance of a mass in the neck. Usually the swelling is painless and slow in development, and, as a rule, is definitely related to the anterior border of the sternocleidomastoid muscle. The mass may vary from the size of a walnut to that of an orange. In most cases in which a sinus opening is present, there is a history of a preceding operation for a mass or of a spontaneous rupture with subsequent drainage. In all cases of sinus, the opening is invariably along the mesial border of the sternocleidomastoid muscle.

In the diagnosis of lateral cervical cysts, the following points may be helpful:

They always lie in relation to the anterior border of the sternocleidomastoid muscle. Invariably they are deeply attached, the skin and the subcutaneous tissues moving over them. The only exception to this rule is in the case of infection of the cyst, when the diagnosis is made more difficult by the inflammatory reaction. The cysts are most often mistaken for cervical lymph-node enlargements of either a tuberculous or a chronic inflammatory nature The differentiation can be made, however, by the absence of any other cervical lymph-node enlargements and by the fact that if the process is inflammatory and of long duration, there would certainly be inflammatory induration with extension to the subcutaneous tissues and the skin. Usually, these cysts lie rather high in the neck (Fig. 222), and this position distinguishes them from cystic hygromas, which almost invariably are found in the lower portion of the neck. In addition, the hygromas

tongue is then excised, approaching the finger at the foramen cecum. It is practically impossible to identify the tract in this tissue; therefore, a tubular excision about 6 mm. in diameter is made up to the foramen cecum. When the dissection has reached the mucous membrane of the floor of the mouth, the tract is excised and the cavity is obliterated with interrupted sutures of fine catgut (Fig. 221).

The operation as described by Sistrunk[19] entails the suture of the divided hyoid bone and the insertion of a drain to the deepest portion of the cavity. The tissues then are closed in layers about the drain The skin closure may be performed with clips or fine wire sutures. In the experience of the author, a thorough obliteration of dead space along the tract obviates the necessity of introducing the drain. The results of this operation are almost 100 per cent cure.

Carabba[4] has suggested the treatment of thyroglossal cysts and fistulas by the injection of a sclerosing solution. He has employed the following technic:

A needle is introduced into the cyst, and, after aspiration of fluid, a dose of the sclerosing solution, varying from 2 to 4 cc., is injected into the cyst cavity, depending upon the size of the cyst and the age of the patient. In young children, smaller doses, of about 1 cc., are used. In the majority of these cases, there is a slight inflammatory reaction, of which the patient should be warned prior to injection This reaction subsides in about 3 weeks, after which time a second injection may be made. Usually, only 2 injections are necessary to affect a cure.

For the technic of injection of the thyroglossal sinuses, see the description given on pages 320-321 for injection treatment of cervical sinuses.

Lateral Cervical, Branchial or Branchiogenic Cysts and Fistulas

Etiology. For a long time, lateral cysts and sinuses in the neck were thought to arise from incomplete closure of the branchial arches. It was believed that these arches formed a continuous layer of epithelium from the skin to the mucosa of the pharynx and thus resulted in a fistulous tract or in the development of cysts. However, the painstaking dissection of embryos by Wenglowski[21] has changed the belief concerning the etiology of these cysts and fistulas. Wenglowski believes that they arise from remnants of the embryologic thymic duct, which extends from the pharynx laterally and slightly downward to the area between the angle of the jaw and the lobe of the ear. Thence it passes downward and forward to the sternum, where it joins the gland substance, lying close to the lateral border of the thyroid gland and medial to the anterior border of the sternocleidomastoid muscle.

The thymic duct theory of Wenglowski[21] is fairly well accepted in surgical literature as explaining the development of lateral cervical cysts and fistulas. There are, however, certain cervical fistulas opening internally in the supratonsillar fossa which must have some other etiology, namely, from the branchial pouches, because the thymic duct arises from the third pharyngeal pouch whereas these cysts mostly rise higher than that level.[1,3]

The embryologic remnants which form the cysts and the fistulas in the neck may communicate with the pharynx, may appear in the neck without

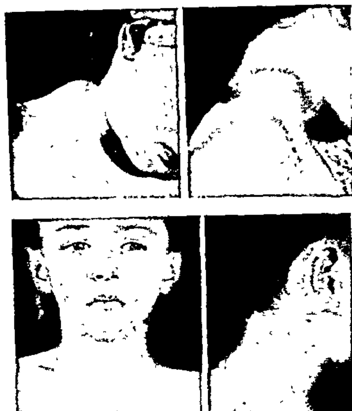


FIG. 221. Cystic hygroma of neck in a 20-month-old child before and after excision. (Gross, Robert E., and Goeringer, C. Fred: Surg. Gynec. & Obst. 69:18 60)

cures. The technic is similar to the one described above In their cases, the sinus tract was visualized by the injection of Lipiodol and then was injected with Carnoy's solution, care being taken to protect the internal opening of the cervical sinus with cotton. After the injection of Carnoy's solution, the tract was irrigated with saline. There was little postoperative discomfort following the procedure, and, in the 3 cases reported, a clinical cure was produced.

CYSTIC HYGROMA

Etiology. A hygroma is a thin-walled cystic tumor which contains lymph and is lined with endothelium. These cysts are congenital in origin in *that they arise from the persistence of* an embryonal lymph sac, which is the earlier form of lymphatic tissue. The persistence of these lymph sacs produces a cystic swelling in the lower portion of the neck (Fig. 224). The sac may extend below the clavicle and even into the mediastinum. Frequently, the cysts are multilocular. They appear most often in infants and children under 5 years of age, but they may occur in adults.[7,15]

Symptoms and Diagnosis. The symptoms of cystic hygroma are few except those of a tumor. In a few cases, however, the cyst may have become so large as to produce dysphagia and dyspnea, especially in children and in infants. They may occasionally become secondarily infected from adjacent infection in cervical nodes. The diagnosis must be made from branchial cysts, lipomas and other such *tumors of the neck. Usually,* this is not difficult because these are the only tumors of the neck which transmit light. They are soft and fluctuant, the

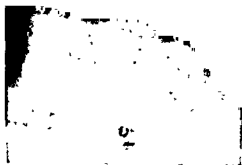


Fig. 223. Branchial fistula. This fistula extended upward along the anterior border of the sternocleidomastoid for a distance of about 3 in. Injection showed that it did not enter the pharynx. The fistula closed following 2 injections of Carnoy's solution.

are soft and may be transilluminated, whereas the cervical cysts are firm and can never be transilluminated.

In diagnosing the lateral cervical fistulas, the location of the fistulous opening along the mesial border of the sternocleidomastoid is in itself almost diagnostic. Usually, there is only a single opening. Injection of the tract with Lipiodol or some other liquid opaque to the roentgen rays will outline its extent and course very definitely

Treatment. The treatment of lateral cervical cysts and fistulas consists of complete excision of the tract. This operation is perhaps best performed under general anesthesia and on a hospital patient. However, the discussion is included in this text because of the importance of making a differential diagnosis in these cases. As a matter of fact, some of the smaller cysts may be excised easily enough under local anesthesia in ambulatory patients.

There have been several reports in the literature concerning the treatment of branchial cysts and sinuses by the injection of sclerosing solutions. Carabba[4] has treated branchial cysts in this manner. After aspiration of the cysts, he injects from 2 to 4 cc. of the sclerosing solution (p. 17). After the injection, there is usually a slight inflammatory reaction which takes 2 or 3 weeks to subside entirely. After this time, reinjection may be necessary.

In the treatment of cervical sinuses, the sinus opening is injected with the sclerosing solution, a broken-off 25-gauge Luer-syringe needle being used as a cannula. This is inserted firmly into the opening of the sinus, and 2 cc. of the solution is injected under pressure. Either the cannula is held in place or a pressure pad is placed over the sinus opening for a few minutes to prevent immediate leakage of the solution. The excess solution is then permitted to drain away. There may be a temporary burning sensation which, in 24 to 48 hours, is followed by a rather marked inflammatory reaction consisting of redness, swelling and some pain. Usually, there is no general reaction. The local inflammation gradually subsides in about a week and often a single injection will produce a closure of the sinus for a considerable period. Usually, a second or a third injection is necessary. The repeated injections are not made, however, until after the inflammatory reaction from the previous injection has subsided entirely.

Cutler and Zollinger[5] have reported upon the use of a modified Carnoy's solution (p. 17) as a sclerosing agent in the treatment of cervical fistulas (Fig. 223). They report 3 cases in which injection of this solution produced what appeared to be permanent

to feel it, and it is, therefore, difficult to locate the selected node. Missing the nodule by ½ inch in one direction or another may give the surgeon considerable difficulty. Therefore, as soon as the anesthetic is injected into the skin, it is wise to make a small scratch mark over the center of the nodule which is to be removed. An adequate incision must be made through each succeeding layer of tissue, skin, subcutaneous tissue and platysma until the nodule is reached. The use of sharp rake retractors in this type of operation keeps the tissues on tension and prevents bleeding, which is troublesome in dissection in a small wound.

When the lymph node has been located, it should not be grasped, but the tissues should be divided and retracted so that it can be dissected bluntly with a curved mosquito hemostat until it is eventually delivered through the wound. This dissection without rupturing the node or without touching it is a work of considerable skill. It is most helpful if one corner or one end of the node can first be dissected free; then, with a hemostat grasping the connecting tissue over the node, it can be elevated and dissected from the bottom. The most adherent portions of the node usually contain the vessels, and it is wise to divide these pedicles between small hemostats before cutting them. The hemostat on the gland portion often serves as a good tractor in elevating the node.

When the gland has been removed, the remaining wound is obliterated, buried sutures being used to catch the circumference of the wound, with mattress sutures of wire, silk or cotton in the skin. Unless there has been some difficulty with hemostasis, drainage is not necessary and a pressure dressing is applied.

SPASMODIC TORTICOLLIS

There is a type of spasmodic torticollis which results from a myositis of the sternocleidomastoid muscle. This is a more or less acute form and, although it may disappear spontaneously, while it lasts it may make the patient extremely uncomfortable.

On examination, the muscle is found to be tender and in spasm. The patient holds his head inclined toward the affected side with his chin pulled down to the shoulder.

Treatment. Two methods of therapy may be considered: a conservative one in which local heat or diathermy is applied; or a more recent one in which the muscle or muscles are injected with procaine, 1 per cent solution. It is possible by this injection to relieve the spasms, to set the muscle at rest and to obtain a complete cure in a relatively short time. The injection may have to be repeated once or twice.

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skin moves over them without attachment, and aspiration reveals clear lymph. Aspiration may collapse the tumor completely, only for it to refill rapidly.

Treatment. The accepted treatment is complete removal of the cyst.[13] This may be a somewhat difficult and even dangerous operation if the cyst extends below the clavicle and into the mediastinum. The operation should be performed in the hospital. There are, however, several conservative methods of treatment which may be mentioned in the ambulatory care of these patients. Some surgeons have aspirated the hygroma and followed this by an injection of the cavity with some sclerosing solution. Harrower[11] has used sodium morrhuate with good results. In a cyst from which he aspirated 1½ oz., he injected 2 cc. of sclerosing solution, and 6 days later, after aspiration of 2 oz., he injected 5 cc. There was a slight inflammatory reaction and the tumor disappeared.

Another form of conservative or nonoperative therapy is irradiation. Figi[9] has reported the use of roentgen and radium therapy of the cystic swelling after reducing the size of the cyst by aspiration As more experience is gained by these conservative types of therapy, it is probable that they will supplant operation in the treatment of these tumors. However, Goetsch,[10] in a most comprehensive review of this subject, still strongly recommends surgical removal of the tumors at an early date before infection and extension of the hygroma take place. He reserves the use of irradiation therapy for children under 8 months of age or for older individuals in whom, because of the large size of the tumor, radical excision is too hazardous

MALIGNANT LYMPHOMAS

Differential Diagnosis. In considering the chronic lymphatic enlargements of the neck, a differential diagnosis must often be made from the various types of chronic or malignant lymphomas. These diseases, which are variously diagnosed as lymphatic leukemia, Hodgkin's disease, lymphosarcoma and so forth, may all produce chronic enlargements of the cervical lymph nodes. The diseases are marked by progressive enlargement of the lymphoid tissues of the neck and often are associated with lymphoid enlargements in other portions of the body, especially the axilla and the groin. They are marked by periods of progression often followed by periods of regression. They are always associated with definite changes in the blood picture, anemia and, usually, characteristic changes in the white cells.

Treatment. The treatment of these diseases in ambulatory patients is not recommended, but the fact that they are causes of enlargement of the lymph nodes of the neck must be borne in mind.

Biopsy. Frequently, the surgeon is called upon to perform a biopsy of one of the lymph nodes of the neck for diagnostic purposes. This operation is easily performed in an ambulatory patient. If possible, a superficial node which is discrete and movable in its surrounding tissues is selected. The operation is performed under local anesthesia, usually by infiltration of the skin and the subcutaneous tissues. It is important in operations of this sort that the surgeon mark the location of the nodule because, after the introduction of the anesthetic, it is frequently impossible

.17.

Chest and Breast

INJURIES

Contusions of the Breast

Contusions of the breast, especially in females, are not uncommon injuries. They may be caused by any blunt object or by kicks from struggling children who are being held. The contused area is painful and tender, and there is sometimes an area of ecchymosis. The injury is frequently a source of considerable concern to the patient because of worry lest it produce a subsequent malignancy. However, there is no evidence to suggest that a single local trauma is a factor in the production of malignancy.

Treatment. Most of the contusions are minor in nature and can be treated easily by supporting the breast. A tight bandage, held firmly in place by adhesive or a tight brassière, usually gives considerable comfort and relief of the edema which occasionally occurs. After the first 24 hours, hot compresses or heat by application of an electric pad is of value

Contusions of the Chest

Etiology. In these days, when numerous types of accidents occur, injuries to the chest are not infrequent. In automobile accidents, a person may be struck by the steering gear or thrown against the dashboard, or other types of bruises may be obtained through various mechanisms In addition, contusions of the chest due to blows and, in older people especially, to falls against the side of the bathtub are not uncommon.

Examination for Fracture. In this area, contusions must always be suspected of overlying a fracture of the ribs. The diagnosis is not always possible without a roentgenogram, but one can obtain a fairly certain clinical impression by moving the involved part of the chest cage without pressing upon the injured area. For instance, if the injury is along the side of the chest, with the hands anterior and posterior, the ribs may be sprung by pressing the hands toward each other. This gives excruciating pain at the site of a fracture, whereas in simple contusions, if pain is elicited, it is not nearly so marked.

Symptoms. Contusions in the chest differ little in their pathology from those elsewhere in the body, but the fact that they overlie an area which is constantly in motion with each respiration gives a prolonged period of disability and accompanying discomfort.

Treatment. Immobilization of the area by adhesive strapping which extends beyond the mid-line, front and back, or, better, which encircles the entire chest at the site of the injury, will prevent movement of the chest under the area of contusion and so lessen discomfort (Fig. 225). Immediate strapping is the most effective method of treatment, and this may be applied even though a fracture is sus-

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Treatment. The adhesive strapping which is used for immobilizing the primary lesion will also be effective in controlling the pain of the traumatic pleurisy. In many cases, an anesthetic injected into the area of involvement will also give relief.

Rupture of Costochondral Cartilage

It must not be forgotten that superficial injuries of the chest may cause not only contusions or lacerations of the chest wall or fractures of the ribs but also rupture of the costochondral cartilage. This usually presents less severe symptoms than does a fracture of the ribs, but when diagnosed it is treated in the same manner.

Diagnosis and Symptoms. Upon examination, there is usually an area of tenderness at the costochondral junction, and, at times, movements of the lower part of the costochondral cartilage upon the upper part may be demonstrated. As a rule, however, this injury is not noticed at the time of primary examination and it may not be treated until long afterwards. The author has seen several such injuries in wrestlers, caused by compression of the chest in various grapple holds. In the unrecognized case, there is a sharp, sudden jumping of the lower part of the cartilage over the upper part, which eventually becomes a source of chronic irritation and of pain.

Treatment. When seen and diagnosed early, the treatment is the same as for a fracture of the ribs (Chap. 27), except that as healing is slow, the strapping may have to be continued for from 6 to 10 weeks. The late treatment of this injury is relatively simple, and can be carried out in ambulatory patients. Under local anesthesia, the involved cartilage is exposed and, after freshening the edges of the ruptured cartilage, 1 or 2 stitches of alloy steel wire are placed across the area of fracture. The wound is closed in layers and a bandage of adhesive strapping is applied. Union of the cartilage and relief of symptoms are practically always obtained.

INFECTIONS OF THE CHEST

Furuncles and Carbuncles

These lesions are not uncommon in the chest. Multiple furunculosis frequently occurs under adhesive applied for the relief of chest injuries. Usually it can be avoided by the application of tincture of benzoin to the chest wall before the adhesive is applied.

Treatment. The treatment of these infections is no different from that described for these lesions elsewhere in the body (p. 121).

Axillary Adenitis

Etiology of Acute Type. Axillary adenitis is seen in 2 forms. The usual type, acute axillary adenitis, arises from an infection in the area which drains into the axillary lymph nodes. This may come from the arm or the hand or from the chest wall on the involved side. The nodes involved by such lymphatic drainage are those which lie along the anterior axillary folds just beneath the border of the pectoralis major muscle. In this area, the nodes become enlarged and tender, and often progress to form a suppurative adenitis or axillary abscess (Fig. 226). The position of these glands should be remembered when examining the axilla for the extension of an infection from the arm or the chest wall. All too frequently, the uninitiated will examine in the apex of the axilla, where no nodes may be

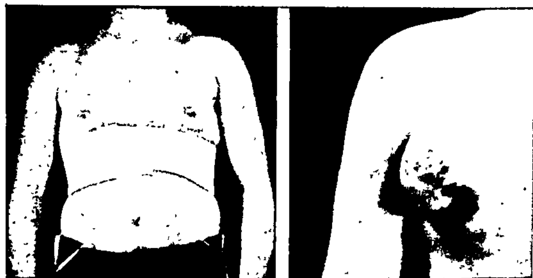


Fig. 225 (*Left*). Circular strapping for contusion of the chest. The strapping is applied with the chest in expiration, the chest being encircled completely to prevent motion of the injured area.

Fig. 226 (*Right*) Large axillary abscess secondary to an infection of the finger.

pected. The application of cold during the first 24 hours and, later, of heat over the adhesive strapping is of value. The acute soreness of the contusion usually is relieved in from 5 to 7 days of strapping, but there may be a residual soreness for a considerably longer period. This may be controlled effectively by the injection of an anesthetic into the area of the contusion. Injections of 1 per cent procaine hydrochloride solution into the area of tenderness often give complete relief. One or two more may have to be given.

Wounds of the Chest

Wounds in the chest are dangerous because they may be associated with wounds in the thoracic viscera. For this reason a careful examination must be made of every thoracic wound. If there is any suspicion of an underlying visceral injury, hospital admission is necessary.

Treatment. The care of superficial wounds of the chest does not differ from that of wounds elsewhere in the body (Chap. 9). After cleansing the wound, if it is not more than 6 hours since the injury was received, primary suture may be attempted. Immobilization is best effected by adhesive strapping which encircles the chest at the site of the wound.

Traumatic Pleurisy

Not infrequently, wounds and contusions of the chest are associated with a reactive inflammation in the parietal pleura, with pain on deep breathing, coughing and sneezing. This is a secondary phenomenon produced by the hemorrhage and the reaction in the tissues of the chest wall, and is given the name traumatic pleurisy. The pleurisy usually is of short duration and clears up with the subsidence of the acute traumatic inflammation.





FIG. 228 (*Left*). Tuberculous abscess of the infraclavicular region.
FIG. 229 (*Right*). Large tuberculous abscess of the axilla and the pectoral fold.

cision is provided, the axillary infection disappears only to have another one develop in a relatively short time. The infective organism is almost invariably the *Staphylococcus aureus*, and this type of recurrent infection occurs in those whose general, as well as local, resistance is reduced.

Treatment of Axillary Furunculosis. Hot wet compresses are applied in the axilla until fluctuation is apparent, when drainage is necessary. Incision may be performed under local anesthesia without much fear of spreading the infection. The author has incised numerous such abscesses under both local and general anesthesia, with practically the same results The infecting organism is the staphylococcus, which should be controlled effectively by antibiotic therapy. The importance of sensitivity tests is shown in this type of lesion, because often the organisms are found to be resistant to penicillin. The infection is usually controlled by the effective antibiotic.

In recurring infections, there is a chronic involvement of the cutaneous apocrine glands and the surrounding subcutaneous fatty tissue. Sinuses often form; they are lined by granulation tissue and drain almost continuously. This condition is called hidradenitis suppurativa. Simple incision may be insufficient to clear up the chronic infection. In such cases, best results are obtained by excising the involved area and covering the defect with a split-thickness skin graft.

TUBERCULOUS ADENITIS AND ABSCESSES

Tuberculosis of the nodes of the axilla is not uncommon, though it is not as frequent as tuberculosis of the lymph nodes of the neck. Those most frequently involved are in the infraclavicular region (Fig. 228), and usually the process has progressed to tuberculous abscesses before the patient seeks treatment.

Treatment. Incision and drainage are usually performed in these cases, although aspiration is the preferable treatment if it can be accomplished The abscess secondary to tuberculosis of the axillary nodes often becomes large (Fig 229) and extends underneath the pectoralis major muscle; incision and drainage are the preferable treatment.



FIG. 227 Suppurative axillary adenitis secondary to furunculosis of the axillary hair follicles.

palpated, whereas the involved nodes may be definitely palpated along the chest wall on the mesial wall of the axilla.

Treatment of Acute Type. In the early stages of acute axillary adenitis, local heat in the form of hot compresses with the same therapy to the primary focus often results in a subsidence of the infection and complete disappearance of the involved nodes. Daily injections of from 300,000 to 600,000 units of long-acting penicillin are an important added therapeutic measure. In the later stages, however, the adenitis more frequently goes on to definite abscess formation and must be treated by operation. When the abscess is superficial, it usually may be incised and drained adequately under local infiltration anesthesia. A double-barreled rubber tube, surrounded by packing in the wound edges, will provide adequate drainage. A sling should be provided for the arm. The packing is removed on the third day after incision, but the drains are permitted to remain in place until the drainage has decreased, showing that the necrotic material has liquefied.

In many cases, the axillary adenitis extends underneath the border of the pectoralis major muscle and forms what has been called a subpectoral abscess. This differs in no way from the usual axillary abscess, except in position; treatment is the same

Etiology of Axillary Furunculosis. A second type of adenitis is that which arises from an infection of the skin of the axilla; the primary process is usually a furunculosis which appears in the axilla and the subcutaneous tissues, and eventually the underlying lymph nodes become involved (Fig. 227). This lesion is an extremely difficult one to treat; one area of necrosis after another appears and slowly develops fluctuation. When in-

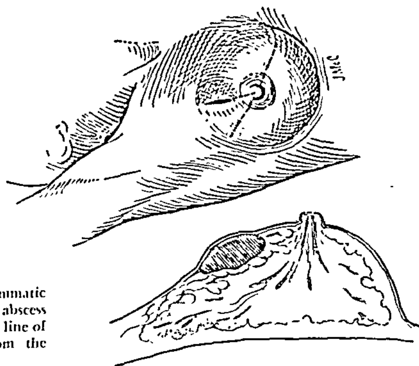


Fig. 232. Diagrammatic drawing of superficial abscess of the breast. Note the line of incision radiating from the nipple.

appear as superficial reddish, tender fluctuant areas, and are best treated conservatively by supporting the breast and applying hot moist dressings until definite fluctuation occurs. An incision radiating from the nipple is then made under line infiltration of procaine anesthesia (Fig. 232). After gently sponging or aspirating the retained purulent material, a small gauze or iodoform pack or rubber dam is inserted for drainage. The breast support and hot wet dressings are continued, and the packing is removed on the third or fourth day. Healing usually takes place rapidly.

Treatment of Intramammary Abscesses. The second type of breast abscess is located in the mammary tissue itself. These abscesses, which almost invariably follow an acute mastitis, make the breast more prominent and cause tenderness on pressure and subcutaneous edema. The tenderness is most marked over the abscess itself. Fluctuation can usually be demonstrated, although this may be more difficult than in the subcutaneous abscesses. Incision, under inhalation or intravenous anesthesia, should be made in a line radiating from the nipple to the periphery over the most prominent part of the abscess (Fig. 233). After the cavity has been entered through a small incision, the finger is introduced into the opening and the cavity is explored. Usually, numerous pockets of pus are found; these are divided by septa, and may be broken up by the finger. If the exploring finger demonstrates a more dependent position for drainage, a second radiating incision should be made over that area and drainage instituted through the second wound. Rubber-tube drainage is better than gauze packing, although gauze may be used to pack the subcutaneous wound round the tube. Support and hot wet dressings are the immediate

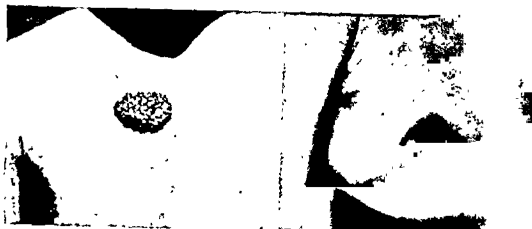


Fig. 230 (*Left*). Large pigmented nevus of the chest wall excised under local anesthesia.

Fig. 231 (*Right*). Superficial abscess of the breast. In this case there are 2 abscesses, 1 subareolar and 1 subcutaneous.

In caring for patients with tuberculous nodes or abscesses, one must bear in mind the necessity for general hygienic treatment for the tuberculosis. It is well to have such patients *under the direct* care of the internist as well as of the surgeon.

TUMORS OF THE CHEST WALL

Sebaceous Cysts

Sebaceous cysts are not uncommon *on the chest wall*. They usually affect the upper portion of the chest, anteriorly and posteriorly, and frequently become infected.

Treatment. Their treatment is the same as for sebaceous cysts elsewhere on the body (p. 179).

Pigmented Nevi

These tumors are often seen in the chest, in areas where constant irritation makes their removal imperative (Fig. 230).

Treatment. Pigmented nevi may be removed under local anesthesia, a generous area of surrounding skin being excised. The looseness of the skin of the chest wall permits easy closure of the wound without marked tension.

Lipomas, Fibromas and Fibrolipomas

These lesions are often found on the chest, most frequently in the upper part, posteriorly over the scapula. They may grow to a considerable size.

Treatment. Removal of these lesions under local anesthesia is easy; they are treated in the same manner as lipomas elsewhere on the body (p. 189).

ABSCESSES OF THE BREAST

Etiology. Mammary abscess occurs most frequently during the early or the late stages of lactation. It frequently follows a mastitis or ordinary retention of milk secretion; or it may result from an infection which enters the nipple through a fissure or a crack.

Treatment of Superficial Abscesses. Superficial abscesses lie in the subcutaneous tissues, anterior to the breast. They may be subareolar or subcutaneous in position (Fig. 231). They

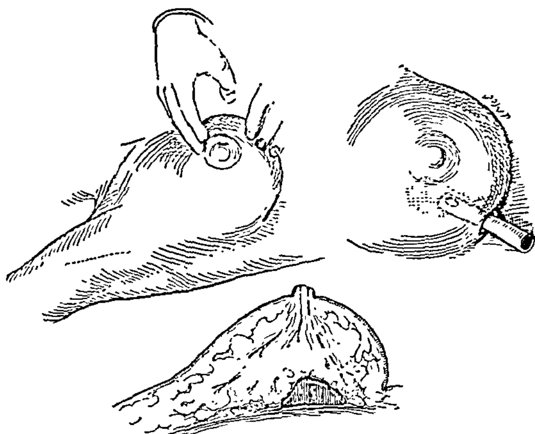


Fig. 234. Retromammary abscess diagrammatically shown underneath the breast. Note the line of incision in the fold of the breast and method of drainage by tubes.

latory patients. In the postoperative care, the gauze packs are usually removed on the third or the fourth day. It is well to instruct the patients to use hot compresses before they present themselves for dressings; this facilitates removal of the packing, after which none is reinserted. The rubber tube is left in place as long as there is much drainage of necrotic material; irrigations through the tube are an effective method of hastening the removal of slough and of obtaining a more rapid cleaning up of the abscess cavity. Incidentally, this method of abscess cleansing is much less painful than that of swabbing with cotton balls. A snug bandage or a tight binder is of great advantage in treating infections of the breast. The edema which occurs in large pendulous breasts often gives more postoperative discomfort than does the abscess itself; this can be relieved largely by effective support. In all these infections of the breast, the use of the antibiotics will aid in the control of the invading organisms, and, if they are given early, may prevent the necessity for incision. If pus is present, however, incision and drainage must be carried out.

SUBCUTANEOUS FAT NECROSIS OF THE BREAST

Necrosis of the subcutaneous fatty tissue of the breast is mentioned here because it is a benign lesion, and,

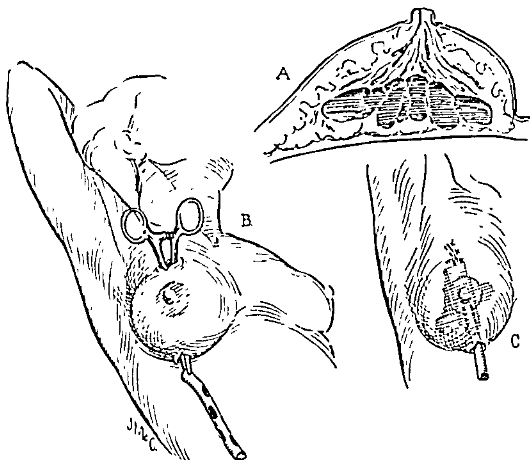


Fig. 233 Intramammary abscess, method of drainage with through and through tube insertion.

postoperative procedures; as soon as the profuse drainage subsides, the tubing may be removed and the cavity permitted to heal.

Treatment of Retromammary Abscesses. Retromammary abscess arises on the undersurface of the breast in the areolar tissue between the breast and the chest wall. As the abscess is overlaid by breast tissue, it is somewhat difficult to palpate it, but the very depth of the tenderness and the lack of definite fluctuation are aids in diagnosis. Drainage of this type of abscess is best accomplished by an incision along the folds of the breast, usually laterally, between the chest wall and the breast itself (Fig. 234) A small incision is deepened until the breast tissue is palpated with the exploring finger; the breast is then raised on the finger and the exploration is carried deeper to the tissues underneath When the abscess is reached, the pus escapes and the cavity is explored to determine whether there is a more dependent position for drainage. A counterincision may often be indicated. Rubber-tube drainage with packing in the superficial wound gives good results.

Postoperative Care of Breast Abscesses. All these types of breast abscess may be taken care of in ambu-

The Indeterminate Stage of Adenofibrosis

The earliest stage of adenofibrosis is an indeterminate one. The patient is usually in her early thirties. She is well nourished and is not of the nervous type. Menstruation is usually regular, and either she is nulliparous or has not been pregnant within 5 years. Married women who have this trouble are frequently sterile.[15]

Cyclic mammary pain occurs, which at first is slight and premenstrual in character. It becomes more severe as time passes and finally extends throughout the cycle, though maximum intensity is reached just before the period. In the early stages, the painful, tender area is usually located in the upper outer quadrant of the breast. The pain frequently is referred to the neck, the axilla, the shoulder, the arm and the lateral thoracic wall.

On examination, a flat granular or nodular area of increased density can be palpated. This differs from a true tumor in that the margins cannot be felt with the breast pressed flat against the chest wall. However, when the breast is raised, a roughly circumscribed area can be outlined and often involves the whole quadrant. The nodularity at first is more marked before the menstrual period and may be almost undetectable in the interval. Later, however, it persists throughout the cycle. Spontaneous regression of this condition may occur, but frequently, after a period of months or years, it will progress to the formation of adenosis or, less frequently, of cystic disease.[15,16]

The areas of increased density may show nothing more than edema of the perilobular connective tissue. Other cases show a striking increase in the fibrous tissue. On section, the nodular area is firm, white and glistening. The adipose tissue is practically absent, and the lobules are distorted by the overgrowth of connective tissue; glandular overgrowth is also usually present.[21]

Adenosis

The indeterminate stage of painful breast may be followed by adenosis. The patient is usually a nullipara in her late thirties. She is apt to be tall, high strung, nervous, frigid, underweight and visceroptotic and suffering from functional gastro-intestinal disorders. Frequently, the thyroid gland is enlarged, and an adenoma may be present. Menstruation is likely to be painful and irregular, and the cycle is shortened to 26 days or less with short, scanty flow.[6,15]

On palpation one finds flat areas of increased density, indefinite nodules and multiple discrete, shotty masses, usually distributed at the periphery. One or both breasts may be involved. The breast is decreased in size and increased in density. It has a saucerlike or liverlike edge. Pain is a prominent symptom, and bleeding from the nipple occurs in about 7 per cent of the cases.

The histologic picture is one of epithelial proliferation with the formation of intracystic papillomas and nonencapsulated fibroadenomatous areas.

Usually, the condition terminates with the formation of multiple small cysts. Pregnancy or the menopause may cause the disappearance of adenosis, but spontaneous return to normal before the menopause is rare.

Etiology of Painful Breast. The etiology of painful breast is not certain. Inflammation or obstruction of

when a definite diagnosis can be made, it can be treated easily in the ambulatory patient. However, its diagnosis often is so difficult that usually it is not advisable to treat it without hospitalization. The reason for this is that fat necrosis so closely simulates carcinoma that a diagnosis cannot always be made with certainty.

Etiology and Diagnosis. Fat necrosis of the breast occurs most often in the *adipose tissue of the upper part of the* breast. It was first described as a clinical entity by Lee and Adair[14] in 1920. It may occur at any time, but it is more common in the fourth and the fifth decades. A history of trauma is not always obtainable, although Lee and Adair were able to obtain such a history in 70 per cent of their cases.

The lesion occurs as an area of edema and eventual necrosis of the subcutaneous fatty tissues, a mass forms and may increase progressively in size. Pain and tenderness usually occur, but they are not invariable. The progressive increase in size, the firmness of the tumor and the frequency of its adherence to the skin suggest cancer as a diagnosis. Furthermore, retraction of the nipple occurs in about 10 per cent of the cases, due to involvement of the fibrous trabeculae that extend to the nipple.

Treatment. Simple excision of the traumatic area of fat with primary suture is all that is necessary if the lesion can be recognized. However, in the majority of cases reported, radical resection of the breast was performed because the lesion was believed to be carcinoma. The extreme difficulty of diagnosis in these cases makes it necessary to have facilities at hand during operation for a radical amputation in case carcinoma is encountered; therefore, these patients are best hospitalized for operation.

PAINFUL BREASTS IN YOUNG WOMEN

Terminology. This condition presents a varied histologic picture and is described under a host of names, the most common of which is chronic mastitis or chronic cystic mastitis. These terms are poor, in that they *infer that the condition is inflamma*tory in nature, whereas present opinion is that this is not the case in most instances. Taylor[21] has suggested the more general and descriptive term adenofibrosis. Other terms, such as *mazoplasia, Schimmelbusch's disease* and mastopathia cystica, are found in the literature.

Painful breast is a benign condition. It is the symptom of pain which focuses the patient's attention on her breast and, in these days of lay popularization of medical literature, causes her to fear cancer.

Painful breast is limited to the age group between puberty and the menopause. The average age of those presenting this complaint in Taylor's series was 30.7 years.[20] He has shown that an active ovary producing estrin must be present.

Symptoms. A considerable percentage of women experience a premenstrual sense of fullness and heaviness of the breasts with actual increase in size. In some they become quite tender, and shooting, stabbing or aching pains are felt. Hyperemia of these organs is indicated by darkening of the areola and dilatation of the superficial veins. Histologic sections show increased development of the lobules with edema of the surrounding connective tissue.[21]

BENIGN TUMORS OF THE BREAST

Benign cutaneous tumors, such as papillomas and moles, may occur on the breast as they do elsewhere in the body. They are easily treated by excision under local anesthesia.

Intracystic Papillomas

Description. *Intracystic papilloma* is a tumor which usually occurs in the region of the nipple or the mid-zone of the breast in women who are near the menopause. About one half of them are accompanied by a bloody discharge from the nipple. The tumor may also be palpated as a soft, smooth or tense mass, usually freely movable; when transilluminated, it is dark. Geschickter[8] reports that 95 per cent of 160 benign intracystic papillomas occurred beneath the nipple or in the mid-zone.

Pathology. Pathologically, these tumors consist of branching stalks of fibrous tissue overlaid by orderly rows of columnar epithelium. They often lie in a cystic formation of the duct, and a bloody discharge is often found in the cyst. Though they are usually benign, the possibility of malignant degeneration should not be overlooked.

Treatment. Excision under local anesthesia is acceptable treatment if the tissue removed can be examined by the pathologist at an early date. If the excised tissue shows no evidence of malignancy, no further treatment is necessary. If there is involvement of the neighboring ducts, mastectomy should be performed.

Fibroadenomas

Fibroadenomas of the breast are common tumors in females during puberty or early youth. They appear most commonly in the upper and outer quadrant of the breast near the periphery; they are usually hard, freely movable smooth masses, and, in about one third of the cases, they are painful.

Treatment. Excision under local anesthesia is easily performed. Usually, the tumor may be turned out of its bed, the resulting dead space being obliterated by tiers of fine catgut or silk, with skin closure of silk, dermal or fine alloy steel wire. A pressure bandage is applied. The tissue removed should be carefully examined for malignancy. Although fibroadenomas in young girls rarely show evidence of carcinomatous degeneration, in older women there have been numerous reports of malignant change. This is one indication for removing such lesions.

Cysts of the Breast

Description and Diagnosis. Solitary cysts of the breast occur in the late thirties and in the forties,[4] that is, about the time of the menopause; this is a diagnostic point of importance. It is generally agreed that breasts containing single or multiple simple cysts rarely develop carcinoma. There is evidence that carcinoma may develop in the intercystic portion of breast tissue, although this rarely ever happens in the area of the original tumor itself. The cysts may appear in any portion of the breast, and, on examination, they are palpated as firm, rounded discrete masses. Depending upon the tenseness of the cyst, fluctuation may be easy or difficult to demonstrate. The finding of definite fluctuation and the absence of inflammatory changes usually make the diag-

the ducts does not seem to be an adequate explanation of the pain, though the edema of the connective tissue round the lobules and the fibrosis may cause discomfort by pressure and tension. The explanation most widely accepted is an endocrine imbalance, either excessive or decreased production of estrin, progestin or some pituitary factor. Taylor, however, has been unable to demonstrate such quantitative changes of these hormones in the blood or the urine of patients with this disease. He calls attention to the frequently associated pathologic changes in the pelvis, especially follicular cysts of the ovaries and chronic parametritis. On this he predicates some neurogenic factor in chronic mastitis.[20] Others have called attention to the high-strung, nervous type of individual who is subject to adenosis and believe that there is a strong psychological element in this condition.

The role of chronic mastitis as a precancerous lesion is a matter of debate. Lewis and Geschickter[15] found that only 1 per cent of their cases of adenosis developed carcinoma in a 5-year follow-up. Others, however, find carcinoma of the breast associated with from 15 to 20 per cent of certain cases of chronic cystic mastitis.[10] Warren's study[23] indicates that "adenoma is without significance as regards subsequent malignancy," but that chronic mastitis and chronic cystic mastitis "predispose to the development of breast cancer." Foote and Stewart's[7] "statistical and morphologic studies indicate that chronic cystic mastitis does play a role in the development of human breast cancer." Clagett, Plimpton and Root[5] followed a large number of cases of chronic cystic mastitis and noted an incidence of carcinoma in 3.3 per cent of this group.

Treatment of Painful Breast. There is no accepted method of treatment of painful breasts. Many patients will improve without treatment of any kind, which makes the evaluation of any particular therapeutic measure difficult. Frequently, a well-fitting brassière which gives adequate support to the breast will afford great relief. Taylor[19] found that 75 per cent of his patients reported improvement or cure when given inactive substances or when irrelevant methods of treatment were used.

Testosterone propionate has also been reported to be of value. The author has had the best results with this form of therapy. Nathanson, Meigs and Parsons[18] inject 1 cc. of testosterone propionate in sesame oil intramuscularly every other day. Treatment is begun about 2 weeks before the next period is expected and continued until menstruation is initiated. This treatment is not given for longer than 3 months. The author has used with considerable success methyltestosterone in the form of Metandren Linguets. They are given in linguets of 5 or 10 mg., 1 daily from the seventh to the twenty-first day of the 28-day cycle. No untoward effects have been noted and the linguets are much easier for the patient to take than are injections. Usually the premenstrual breast pain is relieved in the first cycle the testosterone is taken. It is continued for a second or a third cycle and then discontinued for 1 or 2 periods.

Chronic mastitis is usually a self-limited disease and tends ultimately to regress. However, hormone therapy seems to be a useful palliative procedure at times to avoid operation and to speed regression.

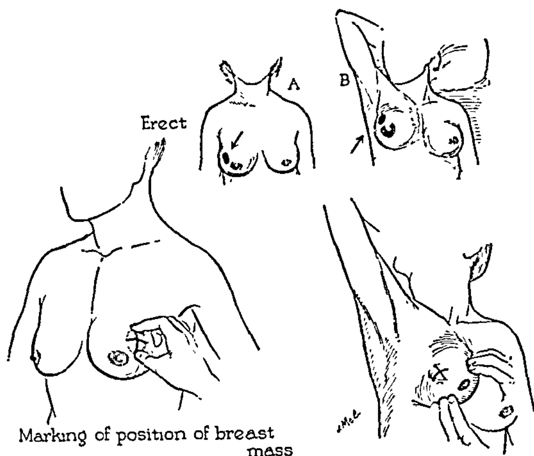


FIG. 235. Showing the change in position in breast masses with the patient in the erect (A) and the supine (B) positions. In operations for removing benign lesions of the breast, the site of the lesion should be marked with the patient in the position she will occupy during the operation.

local anesthesia in ambulatory patients. When the patient has been examined in the erect position, that is, with the breast dependent, it may be somewhat confusing, when the patient lies down, to find that the relative position of the mass has changed. Therefore, before the surgeon starts to scrub up, the patient should be placed on the operating table, with the hand of the affected side under the head, and the site of the tumor should be located definitely by palpation. A nurse or an assistant should hold the breast in the position in which it will be held at the time of operation. A mark in the form of a cross which will stain the skin should then be made directly over the tumor (Fig. 235). This is of value in locating the site of the tumor during the operation, when the mass does not appear directly in the wound.

After scrubbing up, preparing the skin and applying the drapes, the surgeon should palpate the breast carefully again while it is held in the position to be assumed during the operation. It is wise to grasp the nodule between the thumb and the index finger of the left hand while the infiltration of the skin and the subcutaneous tissues over the mass is made

nosis certain. Transillumination is helpful in making a diagnosis, for a cyst is clear like the surrounding breast, whereas solid tumors are dark.

Treatment. Most patients who seek treatment of a solitary cyst of the breast do so because they fear carcinoma. If the diagnosis can be made with a fair degree of certainty, a relatively conservative form of treatment may be carried out, namely, aspiration of the cyst. Aspiration thus is both a diagnostic and a therapeutic measure. It is perfectly safe office procedure. It spares the patient the uncertainty of delay in diagnosis, the trouble of hospitalization and an operation on the breast. If the cyst is entered with an aspirating needle and from 5 to 10 cc. of an opalescent fluid is removed, the diagnosis is made at once, and in the majority of cases the cyst does not reappear. New cysts may appear at other sites in the same or the opposite breast; these may be treated in the same way.

In several cases aspiration was attempted but no fluid could be aspirated. These patients were sent to the hospital for operation. In most cases the cysts were found presenting on the under side of the breast, but in others the palpable mass was found to be a fibroadenoma.

To aspirate a cyst, a wheal of local anesthesia is made over its most prominent portion, and a small incision is made through the skin with a sharp-pointed scalpel. An 18-gauge needle attached to a syringe is then inserted through the skin opening into the cyst. Several types of fluid have been aspirated from breast cysts. If the fluid is straw colored or opalescent, a single aspiration cures the lesion in about 85 per cent of the cases, according to Adair.[1] If the fluid is muddy colored, a single aspiration does not cure nearly as high a percentage of cases. Cysts containing straw-colored fluid with floating flocculi are infected; these always refill no matter how many times they are aspirated. A cyst containing bloody fluid should be considered carcinomatous.

Any cysts containing bloody fluid, or those cysts which refill promptly, should be treated by more radical operation, for which hospitalization is necessary.

In many cases, because of the tenderness of the cyst and indistinct conclusions to be drawn from transillumination, a solitary cyst may be operated upon rather than aspirated. Under local anesthesia, the cyst is exposed after division of the skin and the subcutaneous fatty tissues. It presents usually on the superior surface of the breast as a bluish swelling, and this appearance has given the cyst its common name, blue-domed cyst.[4] It is usually thin walled and, when incised, is found to contain a clear, straw-colored fluid in most cases. Excision of the cyst itself is difficult, but a small amount of surrounding breast tissue may be excised with it. The wound is closed in layers with fine silk or catgut. Skin closure is effected with fine alloy steel wire or dermal sutures. If one can be sure that the lesion is a simple blue-domed cyst, incision permitting the escape of the collected fluid is all that is necessary to effect a cure; the wound may then be closed and a pressure dressing applied without further effort at excision.

Practical Points in Operating on Benign Breast Tumors

There are a few practical points which have proven to be valuable in performing breast operations under

cases of bleeding from this site are benign in origin.[22]

It is evident that bleeding from the nipple must be caused by a lesion in the ductal system or communicating with it. Attempts have been made to predict the nature of the lesion from the character of the bloody discharge. It is apparent, however, that any bleeding occurring close to the opening of the duct will be bright red. On the other hand, a more deep-seated lesion, either benign or malignant, may afford sufficient time for the blood to undergo varying degrees of change before it appears at the nipple.

All discharges from the nipple in a nonlactating breast must be considered pathologic in nature. A nonsanguineous discharge should not lull one into a sense of false security, for the secretion in cases of carcinoma may be serous[12] and, more rarely, even somewhat purulent or milky in nature. Ten per cent of sarcomas give rise to a serous discharge.[12]

Lesions Causing Bleeding. The most common benign lesion causing bleeding from the nipple is papilloma of the duct.[12] This occurs usually in patients in the late thirties or the early forties. It arises in the region of the areola and may be asymptomatic. These papillomas may reach several millimeters in length and may be multiple. Though they most often give rise to bleeding, the discharge is serous in some cases. The bleeding may be intermittent, so that spontaneous cessation of discharge must not be interpreted as a disappearance of the lesion. A superficial papilloma may be large enough to be palpable, or it may cause enlargement of the duct due to obstruction. This cyst can be emptied by pressure, and the fluid appearing at the nipple may be sanguineous. Occasionally, the location of the papilloma may be determined by a point of localized tenderness. The papilloma in itself is benign, but it is prone to undergo malignant change.

Another related benign lesion causing bleeding is the papillary cystadenoma. This is also found close to the areola. It is a cystic enlargement of the duct which is filled with an arborescent papillomatous growth. It also may be multiple and is a precancerous lesion.

Cystic disease of the breast may give rise to bleeding. Trauma may also cause bleeding, but the history of injury and the grossly evident ecchymosis and damage to the breast establish the diagnosis in such cases. The hematoma resulting from such injuries shows irregular densities on transillumination and may require several months for complete absorption. Other benign lesions which cause bleeding from the nipple are fibroadenoma, chronic periductal mastitis, lymphangioma, hemangioma, tuberculosis and the varicocele of Bloodgood. Rarely, no lesion can be demonstrated even on microscopic section. The bleeding in such cases seems to be evidence of an endocrine disturbance; at times it may represent vicarious menstruation.

Gray and Wood[11] found papillary adenocarcinoma of the breast in about half their patients with a discharge from the nipple, and they emphasize the fact that in 60 per cent of their patients with a discharge from the nipple who showed malignant papilloma, no tumors were palpable.

Choice of Treatment. It is evident that bleeding from the nipple simply indicates some pathologic change and is not a diagnostic feature. The treatment of such cases, therefore, requires careful judgment on the part of the surgeon. The practice of radical mas-

with the right. Then, before letting the mass go and before attempting deeper infiltration, a scratch on the skin, longitudinally in the line of the proposed incision and transversely at the mid-point of the mass, is made to mark more definitely the site of the deeper mass. This precaution is taken because, when the edema of the local infiltration is present, the mass may be less definitely palpable and more difficult to find and remove.

When the mass does not appear to have a well-defined capsule which permits its easy enucleation, it is wiser to excise the mass than to attempt further enucleation. Although the mass may be, and usually is, benign, local excision is almost as easy as enucleation and is a surer, safer method of attack. It is frequently possible to excise a wedge-shaped area from the periphery of the breast containing the tumor mass. When this is done, the edges of the breast tissue should be caught with Allis forceps as they are incised. This makes it easy to identify them when they are to be united. In suturing breast tissue, fine sutures of catgut or silk may be used on small curved cutting-edged needles; the tissue is brought together in such a manner as to obliterate dead space left by removal of the tumor mass. Anesthesia is produced by infiltration as the operation progresses, injection being made below and round the breast tissue to block the nerves to the area involved.

Babcock[2] has suggested an ingenious method of removing benign tumors of the breast, without leaving any scars, by making the incision along the edge of the areola. After incising the skin and the subcutaneous tissues, further dissection is carried between the breast and the subcutaneous fatty tissues until the tumor is reached. The tumor is then grasped by Allis forceps and brought into the wound, where it is removed by enucleation; the bleeding points are ligated and the wound is closed. This method of removing benign tumors is applicable only to those which are superficially placed and in a position close enough to the areola to permit them to be delivered through an incision at its edge.

After operating upon the breast, a firm pressure bandage is applied with gauze held in place by adhesive, and the whole breast is then supported by a snug bandage of gauze which completely surrounds the chest and the back. In this manner, the edema which would otherwise occur is prevented, and this reduces greatly the amount of discomfort which follows such an operation. Usually, the patient is provided with from 4 to 6 tablets of morphine sulfate, gr. 1/6, to take every third hour as soon as pain appears. The wounds are dressed on the fifth day; the sutures are removed and another pressure dressing is applied.

BLEEDING FROM THE NIPPLE

General Considerations. Bleeding from the nipple, a rather infrequent finding, is likely to inspire fear and cause the person to seek prompt medical aid. In the recent popular crusades against cancer, the layman has been warned that this symptom is dangerous, and the surgeon will be expected to interpret and treat this condition.

In large series of cases of breast diseases of all kinds, bleeding nipple was a symptom in only 2 to 6 per cent of them.[17,22] The usual age of onset was about the time of the menopause. Though considered at one time as an almost certain indication of carcinoma, some believe that over half the

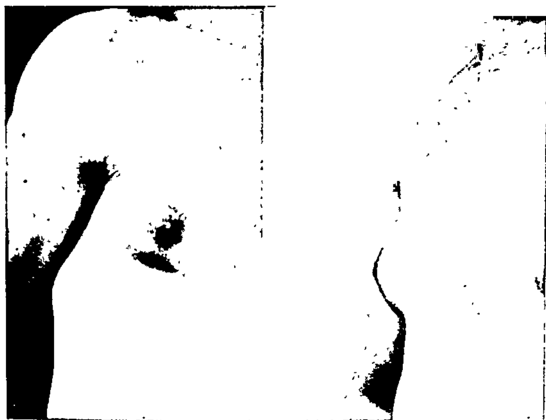


FIG. 236. Gynecomastia in an 18-year-old boy.

cause of the serious character which certain of them assume. Every swelling in the male breast must be treated as carefully as would a swelling in the female breast, and every breast tumor in the male must be regarded as malignant until it is proven to be otherwise. The male breast is subject to infections of various types and, in addition, to mastitis in all its manifestations. The latter condition is the most common of the male breast lesions.

Carcinoma was formerly considered to be the commonest tumor of the male breast. More recently it has been reported that the lesions occurring more frequently are not neoplastic in nature. In a recent series, benign tumors accounted for 34 per cent of breast diseases in the male, carcinoma for 16 per cent, and sarcoma for 3 per cent.[13]

Benign Tumors

Types. Many types of benign tumors are found in the male breast: Fibroma, fibroadenoma, papilloma, papillary cystadenoma, hemangioma, lipoma, sebaceous cyst and epidermoid cyst.

Description and Symptoms. Of these, by far the most common are the fibrous tissue tumors, fibroma and fibroadenoma. This last tumor may be either of the pericanalicular variety, with fibrosis round the ducts and the acini, or of the intracanalicular variety, with connective tissue proliferation into the lumen of the duct or the acinus. These tumors rarely are multiple and occur most

tectomy in all cases presenting this finding is condemned by most authorities. For cases of evident carcinoma, on the other hand, this operation is indicated. It is the remaining group which taxes the skill of the surgeon. Many advise simple mastectomy in all cases of bleeding nipple, with examination of the tissues by frozen section and radical mastectomy if malignancy is found. It is the consensus that, when no tumor can be palpated or demonstrated by other means, simple mastectomy should be performed.

The results of roentgenotherapy in cases of bleeding nipple are uncertain, and this method of treatment is therefore not recommended.

In view of the large number of benign lesions which give rise to bleeding from the nipple, it would seem desirable to resort to local excision in such cases and thereby avoid more mutilating procedures. The conservation of the breast is especially desirable in the younger-age group.

The problem lies in the proper selection of cases for conservative therapy. A single papilloma or a simple cyst may readily be treated by excision, though multiple papillomas require mastectomy.[12] Retraction of the nipple, "orange-peel" skin and ulceration are all significant of well-advanced carcinoma; these signs visible on inspection are likely to be evidences of malignant disease which cannot be treated conservatively. Benign tumors tend to be well localized. Carcinoma, on the other hand, is usually firm and infiltrating, with ill-defined boundaries and possibly regional adenopathy. Sarcoma is extremely rapid in growth, elastic, lobulated and nonadherent.

Transillumination is at times a valuable aid in localizing tumors of the breast. The tumor casts a shadow, while a cyst will be readily transilluminated if the contents are not too opaque.

The usual soft-tissue roentgen studies of the breast have proven to be of limited value. The use of contrast media, such as air or a colloidal solution of thorium dioxide, injected into the ducts from which the discharge arises, opens a new field for preoperative roentgen localization and diagnosis. This method of study is very promising[22] and will reduce the number of mastectomies performed.

If a well-localized, apparently benign lesion can be demonstrated, it may be excised locally with little disfigurement. Babcock has described an ingenious method for local excision of the duct containing a papilloma. The duct is cannulated by means of the blunt end of a needle. An incision paralleling the border of the areola is made overlying the needle, which is then elevated into the wound to aid the surgeon in readily identifying and excising the duct involved.[3] Some object to local excision of the lesion on the ground that there may be multiple lesions which cannot be demonstrated clinically, or that malignant change may be present. Certainly, all these tumors which are removed locally should be examined promptly by frozen section, and the breast must be sacrificed without hesitation if there is evidence of malignancy. When local excision has been carried out, the patient should be followed closely.

DISEASES OF THE MALE BREAST

Tumors

Tumors of the breast in the male, though less common than in the female, also deserve close attention be-

justment to altered hormonal influences. In the adolescent youth, transient slight enlargement, with perhaps tenderness, frequently occurs. The enlargement may be bilateral, unilateral, or even localized to a portion of one breast. This condition usually disappears promptly. In the rarer, more pronounced, cases, such adjustments do not occur and the condition is permanent. The overgrowth may be so striking as to be a source of embarrassment or mental anguish to the patient and may limit his activities. For cosmetic reasons alone, therefore, treatment may be demanded. Though gynecomastia in itself is a benign condition and some consider it harmless, it apparently may be subject to malignant change. In one series of male breast carcinoma, 19.7 per cent showed gynecomastia;[9] for this reason, it should not be ignored.

Treatment. To date, simple mastectomy has been the method of treatment most used. The operation may be performed under local anesthesia through an incision made along the lower half of the edge of the areola This incision may be extended mesially and laterally if desired. Separating the nipple and the subcutaneous tissues from the breast, the breast tissue is then brought into the wound from below and freed from its lateral and mesial attachment as it is turned up from the pectoral fascia. Bleeding is controlled by a pressure dressing after wound suture.

The most recent field of treatment has been endocrine therapy. Promising results have been reported by the use of testosterone propionate. Evaluation of the results is still uncertain, but apparently rather large doses, totaling several hundred milligrams, must be used and the course of treatment carried out over a long period of time. The incidence of relapse when the therapy is stopped suggests that maintenance doses must be continued to maintain any improvement resulting from the treatment. The best results with testosterone propionate have been obtained in those cases in which hypertrophy developed early in adolescence and received treatment shortly after the onset of the condition. Other hormonal preparations, such as the A.P.L. substance, have also been tried, but the results seem to be less favorable.[21]

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frequently during adolescence and old age. They vary in consistency, but tend to be rather firm. On section, they are grayish white in color and fibrous in character. They may show cystic, myxomatous, hyaline, colloid, calcareous, ossific or even malignant change. The entire breast may be diffusely involved in the fibrosis, or the tumor may be rather well localized, though it is never encapsulated. In most cases, there are no symptoms other than the appearance of a swelling in the breast. Certain patients, however, complain of a local stabbing or prickling pain with occasional tenderness.

Diagnosis. In the early stages, the tumor is well defined, smooth or lobulated, and freely movable. In older people, however, it may become adherent to the skin and surrounding tissues (malignant pseudofixation), at times with retraction of the nipple and even palpable regional nodes. In such cases, a differential diagnosis can be made only by microscopic section. True "orange-peel" skin is never produced by these tumors. The differential diagnosis between the fibrous tumors and other benign growths also may not be established preoperatively. This is of little consequence, however, since all benign tumors of the breast should be treated alike, that is, by excision.

The other benign tumors are also likely to be asymptomatic, except for ... with per- ... and oc- ... nipple.

Treatment. The treatment of all benign tumors of the breast is excision because of the fact that early malignant change cannot be determined clinically, and these tumors frequently undergo such change. If the tumor is small and well localized, it may be excised under local anesthesia. Larger and more diffuse growths require simple mastectomy, usually with sacrifice of the nipple. All such tumors should be examined immediately by frozen section, and radical mastectomy should be carried out promptly if areas of malignant change are found.

Malignant Tumors

Malignant tumors of the breast include carcinoma and sarcoma. These account for from 10 to 20 per cent of all male breast lesions. About 2 per cent of all malignant breast lesions are found in the male. Cancer of the breast, however, constitutes only 0.4 per cent of all carcinoma in males.[9] Malignant tumors of the male breast cannot be treated in ambulatory patients.

Gynecomastia

Description and Etiology. Gynecomastia is a condition in which the male breast undergoes hypertrophy, so that grossly and on microscopic section it resembles the breast of an adolescent girl (Fig. 236). In many cases, the onset is at or shortly after puberty; in others, it occurs during senescence. Some are associated with testicular tumors such as chorionepithelioma or teratoma, and there have been reports of cases following prostatectomy. Frequently, atrophy of one or both testes is associated. Some hormonal imbalance is responsible for the hypertrophy, but the exact mechanism is not yet clear.

The hypertrophy usually is bilateral, but it may be unilateral.

Minor manifestations of this condition are rather common at the time of puberty, during the phase of ad-

. 18 .

The Abdomen

Most surgical diseases of the abdomen are intraperitoneal and require hospitalization for their treatment. However, there are a few diseases of the abdominal wall which can be treated in the ambulatory patient.

CONTUSIONS OF THE ABDOMINAL WALL

Etiology and Symptoms. Not infrequently, contusions of the abdominal wall are caused by blows or accidents in which the abdomen is struck by sharp objects. Usually, the injury is a simple bruise of the abdominal musculature which results in ecchymosis and pain on movement of the muscles, especially on coughing, sneezing and straining.

Diagnosis and Treatment. Usually, the diagnosis of superficial injuries can easily be made by the tenderness and the pain elicited when the muscles are used against resistance. If the entire symptomatology is due to simple contusion of the abdominal muscles, it may be well treated by adhesive strapping. If soreness persists, infiltration with local anesthesia often gives a more rapid relief of discomfort.

However, in diagnosing abdominal injuries, the examiner must be aware of the danger of intra-abdominal injury and, for this reason, any severe contusion of the abdominal wall is best treated by hospitalization.

OMPHALITIS

Etiology. An acute inflammation of the navel is usually the result of an irritation produced by retained secretions in the umbilical dimple. This difficulty is especially likely to occur in those in whom cutaneous closure of the umbilicus has resulted in a small opening and in those who are obese. Thus, it is difficult for the sebaceous secretions and the desquamated epithelium to escape or to be washed away in bathing.

Symptoms and Treatment. In milder cases, there is a redness and a slight drainage from the umbilical opening, with some tenderness of the umbilicus and the surrounding tissues (Fig. 237). This usually disappears with the application of hot moist dressings and an attempt to clean the umbilicus thoroughly.

In more marked cases, there is a retention of sebaceous materials and desquamated epithelium, forming a homogenous mass which has been given the name of umbilical cholesteatoma. These masses become hard and even calcified, and produce an irritation which results in an inflammation and abscess formation (Fig. 238). These patients should be hospitalized.

In addition, there is danger that the swelling and the pain at the umbilicus may arise from some intra-abdominal lesion or from an infection of a persistent omphalomesenteric

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jus with the round ligament of the uterus.

Failure of the tubular processus vaginalis to obliterate at the abdominal wall accounts for the appearance of inguinal hernia in newborn babies. The mother or the nurse notes the enlargement of the scrotal sac on one

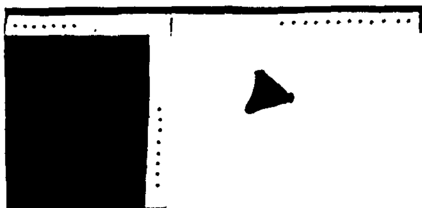
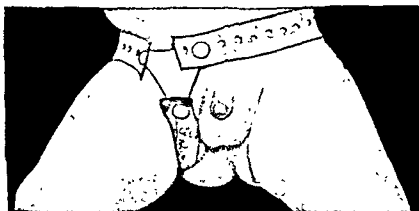


Fig. 239 Truss and binder ready for use. (Potts, W. J.: J. A. M. A. 117:1440)



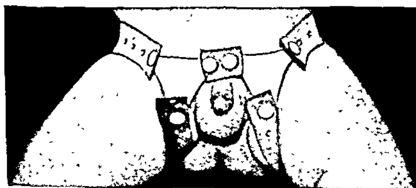


Fig. 240. (*Top*) Truss in place. (*Bottom*) Modification of truss for an infant with a bilateral inguinal hernia (Potts, W. J.: J. A. M. A. 117:1440)



FIG. 237 (*Left*) Omphalitis. In this child, there was a draining, swollen red umbilicus and an infected granuloma at the umbilical opening. The omphalitis cleared up following hot wet dressings and cauterization of the granuloma with silver nitrate

FIG. 238 (*Right*) Omphalitis with abscess formation. In this patient, the abscess was drained by incision under local anesthesia. A cholesteatoma was evacuated, and healing occurred promptly.

duct. It is for this reason that severe infections of the umbilicus require study in the hospital.

HERNIA

As a rule, hernia is looked upon as a lesion requiring operation and hospitalization. There are times, however, when operation is contraindicated or when the patient does not wish it. In such cases, ambulatory care may be called for.

Truss Therapy. Treatment of hernia in ambulatory patients usually consists of the application of a truss, that is, a pad held over the hernial orifice with enough pressure to prevent the abdominal contents from entering the hernial sac. A requirement of truss is that it keep the hernia reduced through the stresses and strains of ordinary life.

The hernias that are most amenable to truss treatment are those of the inguinal type. They present themselves through an area of the abdominal wall that does not move and at a site where adequate pressure may be applied to maintain reduction.

Injection Treatment of Hernia. The injection treatment of hernia is mentioned only to be condemned. It has never been a reliable or a trustworthy method of therapy, and figures now becoming available as to results are not dramatic. In 1937, Maier[1] followed 56 cases he had treated in 1934; only 11 patients had no definite evidence of recurrence, and 9 of these were wearing trusses. In a later checkup of these 11 cases, none was found to be cured. Furthermore, following injection therapy, surgical repair was more difficult because of the marked fibroplasia and the loss of tissue resiliency.

INDIRECT INGUINAL HERNIA

This type may appear at any age from birth to late adult life. The sac of the hernia is the processus vaginalis peritonaei, which descends into the scrotum with the testis in fetal life. Normally, this process is obliterated at birth, only the distal portion of it remaining as the tunica vaginalis of the testis. In females, the processus vaginalis descends to the labium ma-



Fig. 241 (*Top, left*). Hard rubber Hood truss (Henry Saur Co., Inc.)

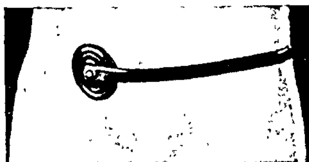


Fig. 242 (*Top, right*). Cross body truss (Henry Saur Co., Inc.)

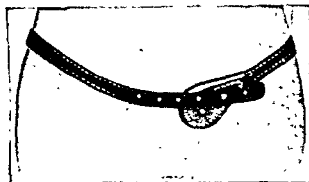


Fig. 243. French style truss. Henry Saur Co., Inc.)

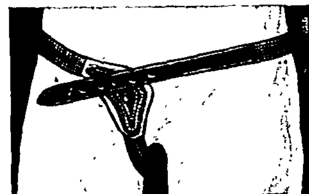


Fig. 244. Scrotal truss (Henry Saur Co., Inc.)

Direct Inguinal Hernia

These are rarely complicated by incarceration or strangulation, and, if they are without symptoms, no treatment is necessary. If pain or discomfort is a symptom, there usually has been a tear in the weakened transversalis fascia with the protrusion through this opening of preperitoneal fat. Trusses similar to those used for indirect hernia may be applied for support, but they frequently do not give symptomatic relief.

Femoral Hernia

It is difficult, if not almost impossible, to keep this hernia reduced by a truss. If the truss maintains reduction it is too uncomfortable for the patient to wear. Trusses are not advised even as an optional treatment in femoral hernia.

Umbilical Hernia

In infants, such hernias often disappear spontaneously without treatment. Those that persist in childhood

or both sides, this is more apparent when the sac is distended by the increased abdominal pressure of crying. The diagnosis is made by inspection and palpation. Almost invariably, these hernias are reducible, but they occasionally become incarcerated. To aid nature in the spontaneous closure of the pouch of peritoneum and to prevent incarceration, a truss should be applied. Potts[2] points out that such a truss must not only retain the hernia under all conditions but be comfortable, nonirritating, sanitary and easy to apply correctly. He uses a pad of white outing flannel. Two triangular pieces of cloth 3 in. on a side are sewed together except for a small space on one side. The pocket thus made is turned inside out to bring the seams inside and is stuffed tightly with cotton. The seam is completed and a small button is sewed to each corner (Fig. 239). The finished pad measures approximately 2 in. from corner to corner.

The binder is made of two strips of pure gum rubber 7/8 in. wide and about 1/50 in. thick; one is 18 in. long and the other 9 in. long. The 9-in. strip of rubber is cemented to the 18-in. strip 6 in. from either end. The long strip goes around the abdomen, the short one across the perineum. From 6 to 8 holes 1/16 in. in diameter and 1/2 in. apart are punched in each end of the long strip, and from 1 to 6 similar holes are punched in the perineal strip. The binder can be used on either side merely by reversing it. The truss is now ready for application (Fig. 240).

The rubber strips will be too long for small infants and can be cut to fit, allowance always being made for the growth of the child. The truss should be applied snugly enough to keep the hernia reduced but not so snugly that it pinches the skin. Unless the child has an unusually large hernial ring, very little pressure is necessary to accomplish this. After the truss has been applied, the child is made to cry to test the effectiveness of the pressure on the pad.

The mother is instructed to make a number of pads, using the one given her as a model. A fresh pad can be applied as often as is necessary for cleanliness. The soiled pads are washed with soap and water and are dried for future use.[2]

Before a truss is prescribed for a patient, the examining physician must make sure that the hernia is reducible. The selection of the truss and its fitting are usually left to the truss fitter, but a few simple suggestions about trusses may be of value. For inguinal hernias in childhood, youth and early adult life, hard rubber pads with a spring type of truss are probably the best to keep the hernia reduced and the easiest to keep clean. Of these, the Hood type of truss (Fig. 211) is good for bilateral hernia, but the "cross body" truss (Fig. 212) is probably the strongest and the best for a unilateral hernia. A French truss (Fig. 213) is a leather-covered spring and single pad that completely encircles the pelvis and straps in the front. It is not usually as efficient as the other types, and it is difficult to keep the leather covering clean. For large scrotal hernias, a scrotal type of truss (Fig. 214) is required, with a large soft triangular pad fitted to lie along the inguinal canal and to extend over the side of the pubis. A perineal strap is necessary to hold this truss in place.

For older people, softer pads may be used. Those of sponge rubber, of leather covered with mole cloth, or even water-bag pads are often employed. Elastic trusses are inefficient but are sometimes useful for night wear.

• 19 •

The Back

ACUTE LESIONS OF THE BACK

In the examination for acute lesions of the back, a basic routine should be followed. A careful history often will give important clues as to diagnosis The examination should be made with the patient disrobed and in a good light, and in the standing, the sitting and the recumbent positions (Figs. 245 and 246).

Posture, gait and visible deformity are first inspected in the standing position, if possible, then the range of flexion, extension and lateral bending is noted. Palpation may disclose irregularity of the spinous processes, acute interspinous tenderness, localized or diffuse muscular or fascial tenderness or spasm, and palpable masses. With the patient supine, the straight-leg-raising test (Fig 247) is made, and, with the patient prone, palpation is repeated and extension of the thigh is tested (Fig. 248). Rotation may be tested as shown in Figures 249 and 250. The patellar and the Achilles re-

Fig. 245 (*Left*). Examination of back with patient in standing position The light comes directly over the shoulder of the examiner, who is seated.

Fig. 246 (*Right*). Examination of back with patient in sitting position Note position of the examiner, with eyes on a level with the middle of the patient's back. Light should be directly over examiner's shoulder

and in youth are best treated by operation. It is doubtful if a truss is of much value in this type of hernia. In the acquired umbilical hernia seen usually in late mid-life in obese patients, an abdominal supporting belt with an "umbilical pad" is sometimes used, although it is doubtful if much other than abdominal support is accomplished.

Incisional Hernia

This lesion is often treated by supporting belts of elastic or webbing, with a pad so placed as to give added pressure over the hernial opening

References

1. Maier, R. L.: The present status of the injection treatment of hernia. Am. Ann. Surg. 122:85-87, 1945
2. Potts, W. J.: A truss for inguinal hernia in infants. J.A.M.A. 117:1440-1441, 1941.

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The Back

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Fig. 245 (*Left*). Examination of back with patient in standing position. The light comes directly over the shoulder of the examiner, who is seated.

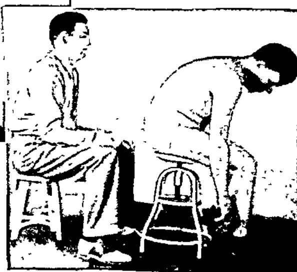


Fig. 246 (*Right*) Examination of back with patient in sitting position Note position of the examiner, with eyes on a level with the middle of the patient's back. Light should be directly over examiner's shoulder.

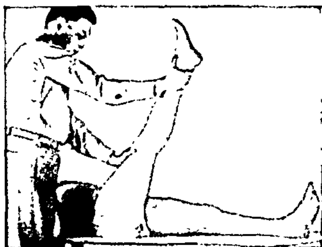


FIG. 217 (*Left.*) The straight-leg raising test. When the lesion is unilateral, such as a herniation of the nucleus pulposus, the leg on the affected side cannot be raised as high as the other, and to force elevation may bring on "sciatic" pain.



FIG. 218 (*Right*). Testing extension of the thigh One hand holds the pelvis against the table, the other hand flexes the leg at the knee and elevates the thigh

flexes should be noted and any sensory disturbances mapped and recorded. When bony injury is suspected, roentgen examination should be requested.

SPRAINS AND CONTUSIONS.

The most common injuries of the back fall into this group Sudden jerking movements, sudden lifting and straining, falls, and the body contacts of certain sports frequently cause these lesions. The patient gives a history of pain that began immediately after the injury or sometimes after a lapse of an hour or two. The pain varies in severity from a mild, dull ache or a "catch" in some movements to a severe, sharp pain that inhibits almost any motion, depending on the severity of the injury. In sprains, sometimes only a single muscle group is involved, while in contusions, the pain at the site of the blow may be accompanied by pain in other areas where there has been abrupt overstretching of muscle or fascia.

Diagnosis. The condition of the back varies with the site and the severity of the injury. Most often the erector spinae muscles and the quadratus lumborum are involved. The pa-

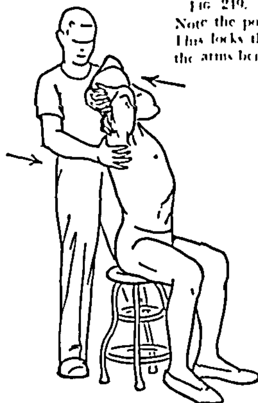


Fig. 249. Passive rotation of the trunk upon the pelvis. Note the position of the patient's hands behind the head. This locks the scapula and permits rotation of the trunk, the arms being used as levers.

ness holds the back rigid so as to prevent stretching the affected muscles. Active motion that requires their contraction causes acute pain and is inhibited reflexly; any passive motion that stretches them is also painful and therefore limited. Muscles that were not injured may participate in the reflex spasm. The injured areas exhibit acute tenderness on pressure. Such areas must be differentiated from the rather diffuse muscular tenderness that appears after a time in muscles or ligaments originally uninjured but later subjected to the constant tension of spasm. Fractures of the vertebral bodies or transverse

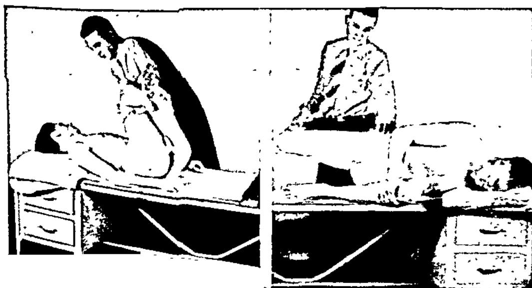


Fig. 250. (*Left*) Testing for flexion and rotation of the pelvis upon the trunk. This maneuver tests for painful motion in the lumbosacral and the lumbar joints. (*Right*) Patient in the side-lying position, testing for pain produced by torsion strain in the sacro-iliac joint. The leg underneath is flexed on the abdomen, the knee being held in the patient's hand. With the pelvis thus fixed, the upper leg and thigh are hyperextended as shown.

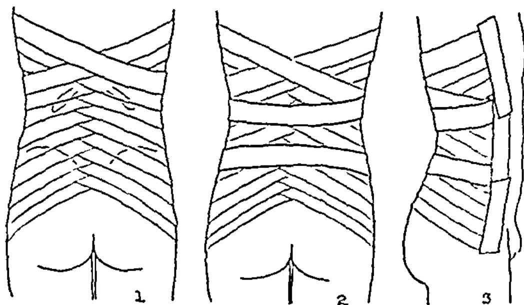


FIG. 251. Adhesive strapping for immobilization of a fracture of a transverse process. (1) A layer of crisscross adhesive is started at mid buttock level and ended at the middle of the thorax. (2) It is reinforced by transverse strips. (3) The free ends are fastened down by longitudinal strips.

processes often cannot be excluded except by roentgen study.

When the lumbosacral and the sacro-iliac areas are involved, the buttock muscles and the piriformis may become spastic, and this may account for the "sciatic" pain sometimes present in the posterolateral thigh and calf. It is often difficult, or impossible, to exclude a disk injury (p. 362), but since the treatment is essentially the same for both in the acute phase, the differentiation at the moment is not too important. When the sciatic pain is severe and persistent, further investigation is indicated.

In severe loin injuries, renal damage should be considered and the urine examined.

Treatment. Treatment is first directed at relieving the pain and the muscle spasm. When well-localized tender areas can be found, each of these is injected with 10 cc. of a 1 per cent procaine solution. In mild cases, the patient may immediately begin moderate activity, avoiding overexertion. *When necessary*, additional injections are given at intervals of 1 or 2 days. In the more severe cases, particularly those in which a shearing force has been applied to the crest of the ilium, strapping (Figs. 251 and 252) makes a useful supplement to procaine injections, and in these cases a few days of rest, the application of ice bags to the injured area, and the generous use of salicylates and phenobarbital is advised. The strapping is replaced or tightened at intervals of from 3 to 7 days unless the skin shows evidence of irritation. Gentle back exercises should be started as soon as the acute symptoms subside. When the strapping is removed, a daily hot tub bath and massage with 10 per cent methylsalicylate help to overcome residual stiffness and discomfort.



Fig. 252. Crisscross strapping of the loin for contusions and shearing injuries at the crest of the ilium

It often happens that symptoms persist for an undue length of time—more than 3 or 4 weeks. In such case, a search must be made for possible contributing or underlying factors, which may be flatfeet, shortness of one leg, working in a strained position, poor posture, poor musculature or chronic structural bony lesions. The back may have "accommodated" to one or more of these over a period of many years, and symptoms may have been slight or absent. However, when an injury occurs in an area of chronic strain, the symptoms of injury may be aggravated and prolonged. This subject is discussed in detail on pages 367-373.

Acute Sacro-iliac Sprain

This diagnosis was made quite often in the past, but the term is now used much less frequently. It is believed that acute symptoms are occasionally due to slight slipping or subluxation of a sacro-iliac joint. This may follow little or much violence. The pain is localized over the joint. There may be spasm of the surrounding muscles.

Treatment in the acute phase is similar to that for other back sprains, with the addition of a firm strapping that completely encircles the pelvis below the level of the iliac crests (Fig. 253). In severe cases, bed rest with traction on the leg of the affected side should be considered. The persistence or the recurrence of symptoms should lead to careful roentgen study.[1] When subluxation or sprain recurs, a firm canvas belt that compresses the pelvis below the level of the iliac crests and limits motion moderately at the lumbosacral area may be prescribed.

Fig. 253 Strapping for sacroiliac sprain, which aims to compress and stabilize the sacroiliac joints. (A) A gauze pad is placed over the pubic hair, and straps 2 in. wide are applied over the lower abdomen. These serve as points of anchorage for the next layer (B), which encircles the pelvis.

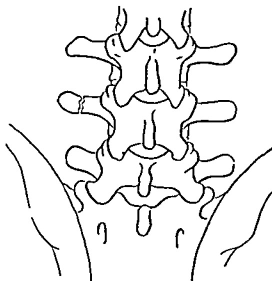


Fig. 254. Fracture of left transverse process, fourth lumbar vertebra. (Ferguson, L. Kraeer, and Erb, W. H.: Ann. Surg. 114:304)

Fractures of the Transverse Processes of the Lumbar Vertebrae

The transverse processes in the lumbar region may be fractured by indirect muscular violence, such as a sudden jerking movement of the back or a fall that causes extreme twisting or lateral bending of the back. Direct violence such as a kick or a blow may also be a cause. The quadratus lumborum muscle attaches to the transverse processes and is torn when the fracture occurs.

Diagnosis. The history of acute violence followed by severe pain on one side of the lower back with intense muscular spasm and tenderness on the side of the lumbar region and pain on lateral b... to ...

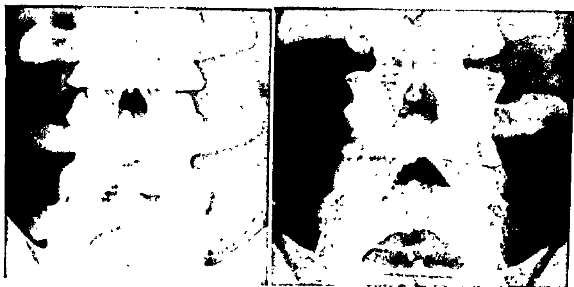


FIG. 255 (*Left*). Same case as Figure 254. Roentgenogram of patient 18 days after fracture showing early callus following 4 procaine injections and adhesive strapping. Patient returned to work, as an inspector, on the fourth day after fracture. (Ferguson, L. Kracer, and Erb, W. H.: Ann Surg. 114:301)

FIG. 256 (*Right*). Same case as Figures 254 and 255. Follow up roentgenogram 7 weeks after fracture; no disability. (Ferguson, L. Kracer, and Erb, W. H.: Ann. Surg 114:301)

site side will indicate the diagnosis. There is often pain on flexion of the thigh of the affected side, especially when resistance is offered. Roentgen examination confirms the diagnosis (Fig. 254-256).

Treatment. Although these injuries are usually treated by rest in bed, patients often make more rapid and satisfactory recovery on ambulatory treatment. Using the roentgen films and local tenderness as a guide, from 10 to 20 cc. of a 1 per cent procaine solution is injected into and round the site of fracture. This gives striking relief of pain and ease of motion. A firm crisscross adhesive back strapping from mid-buttocks to mid-thorax (Fig. 254) supplies adequate support and immobilization. Some discomfort often persists for several days, and the procaine injections may be repeated 2 or 3 times at intervals of from 1 to 3 days. Salicylates and phenobarbital should be given during the first few days.

When only 1 or 2 processes are involved, this simple method produces excellent results without residual symptoms. When several processes are involved, the soft tissue damage may be extensive. In addition to the procaine injections, the treatment program may include a few days' rest in bed and longer use of strapping, or perhaps the application of a light plaster cast from the mid-buttock to the mid-thorax region for 3 or 4 weeks.

Compression Fractures and Dislocations of the Dorsal and the Lumbar Spine

Etiology. Fractures of the bodies of the dorsal and the lumbar vertebrae most often follow hyperflexion or

Fig. 253. Strapping for sacro-iliac sprain, which aims to compress and stabilize the sacro-iliac joints. (A) A gauze pad is placed over the pubic hair, and straps 2 in. wide are applied over the lower abdomen. These serve as points of anchorage for the next layer (B), which encircles the pelvis.

B

A

Adhesive for anchorage

Gauze pad over pubic hair

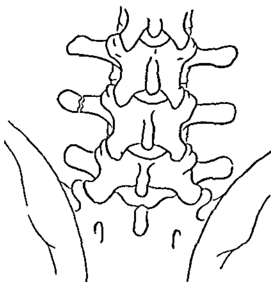


Fig. 254. Fracture of left transverse process, fourth lumbar vertebra. (Ferguson, L. Kraeer, and Erb, W. H.: Ann. Surg. 114:304)

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Diagnosis. The history of acute violence followed by severe pain on one side of the lower back with intense muscular spasm and tenderness on one side of the lumbar region and severe pain on lateral bending to the oppo-

Diagnosis. The signs of fracture vary with the severity of the injury. After a fall from a height that results in a fracture of the os calcis or other bones, the mild pain of a compression fracture of the spine may be masked by the more severe foot or leg pain. The common local signs of fracture are:

1. Muscle spasm and rigidity of the back.

2. Definite acute tenderness over the spinous process of the involved vertebra and the interspinous space below it (Fig. 257).

3. Local pain in the back or radiating pain (girdle pains), or both, usually aggravated by motion.

4. In more severe injuries, a visible kyphos or a local prominence of the spinous processes and a distinct widening of the interspinous space immediately below the involved vertebra.

Additional evidence in the form of diminished motor power in the legs, sensory disturbances and altered reflexes may indicate root or cord compression. Posterior herniation of the nucleus pulposus (see p. 364) may accompany fractures.

Treatment. If the patient is seen where the injury occurred, a rapid examination is made to determine the degree of shock and the extent of bone and cord injury. Morphine is given only for severe pain, and appropriate treatment is started for shock. A severely injured person must be transported with care to avoid further damage. As a rule, the patient is best rolled on to a rigid stretcher or a heavy blanket in the prone position, so that sagging allows some extension of the back to occur.

Those less seriously injured may present themselves as ambulatory patients. If the history and the examination arouse suspicion, an immediate roentgen examination should be made, and, if there is definite compression of a vertebral body, the patient should be admitted to the hospital for reduction by hyperextension. When there is a fracture without displacement, a plaster jacket should be applied in hyperextension, as shown in Figure 258. As soon as the plaster is hard, the patient should resume his normal activities as far as possible.

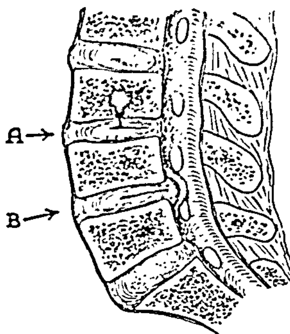


Fig. 259. Herniation of the nucleus pulposus. (A) Extrusion of the nucleus pulposus into a vertebral body (the Schmorl type), usually of little clinical importance. (B) Posterior herniation of the nucleus pulposus causing pressure on a nerve root.

Lesions of the Intevertebral Disks

The elastic disks between the vertebral bodies are composed of a central portion, the nucleus pulposus, which is surrounded by a fibrous ring, the annulus fibrosus, and bounded above and below by plates of hyaline

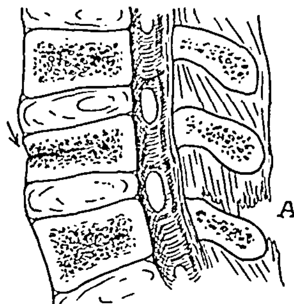
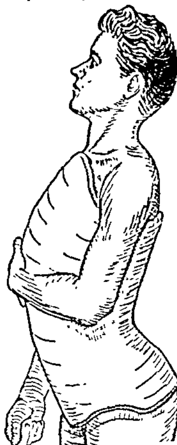
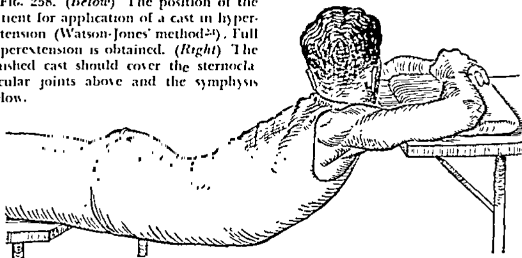


FIG. 257 (*Left*). Compression fracture of the vertebral body. Note the wedge shape produced by narrowing anteriorly. With more compression a kyphos may appear. There will be tenderness below the spinous process of the injured vertebra at (A). The interspinous space may be widened.



compression of the spine, or a combination of the two. Often the violence is not great. Common causes are (1) a fall from a height, landing on the feet or the buttocks (a patient who sustains a compression fracture of the os calcis after a fall from a height should be examined for compression fracture of the spine); (2) a blow on the back while the spine is flexed; and (3) sudden flexion of the spine when an automobile goes over a deep hole at high speed, throwing the passengers upward.

FIG. 258. (*Below*) The position of the patient for application of a cast in hyperextension (Watson-Jones' method[24]). Full hyperextension is obtained. (*Right*) The finished cast should cover the sternoclavicular joints above and the symphysis below.



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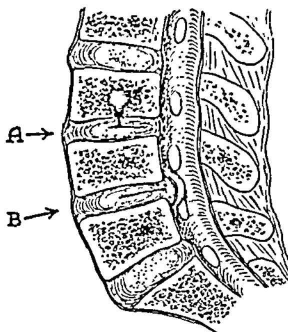


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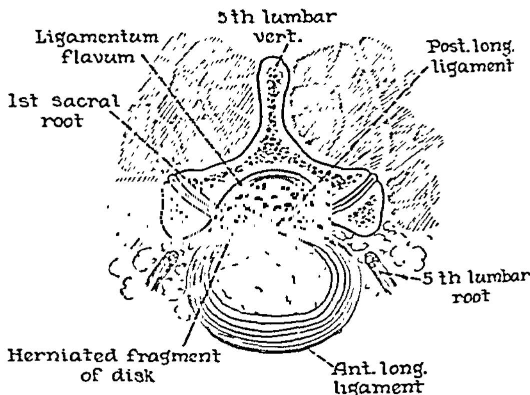


FIG. 260. Cross section through a lumbar intervertebral disk, showing posterior herniation of the nucleus pulposus with compression of root of first sacral nerve.

cartilage. The elasticity of the spinal column is due to these disks.

The nucleus pulposus may be extruded through a defect in the cartilage plate into the vertebral body (Fig. 259A). Symptoms may be absent, or they may be local and mild. Much more important are herniations of the nucleus through a defect in the posterior portion of the annulus fibrosus (Figs. 259B and 260). Such protrusions press on the nerve roots and cause corresponding symptoms. Both types of displacement of the nucleus may be responsible for the narrowing of the intervertebral space seen in the roentgen films, although this finding does not have to be present for the diagnosis to be made. Narrowing of the intervertebral space may also be due to other causes.

Subluxation of the Nucleus Pulposus

Symptoms. It has been suggested[18] that certain episodes of acute back disability are due to posterior displacement, that is, slight subluxation of the nucleus pulposus without actual herniation (Fig. 261). The pain strikes one quite suddenly, while stooping over or straightening up or lifting up from a stooping position. There may be a feeling of a "slip" or "snap" accompanied by an exquisitely sharp, almost paralyzing, pain over the back. The person cannot move for a few moments. This may be followed by a duller pain in the lower lumbar area. The patient holds his back rigid in slight flexion and sometimes bent toward the affected side. Any motion aggravates the pain.

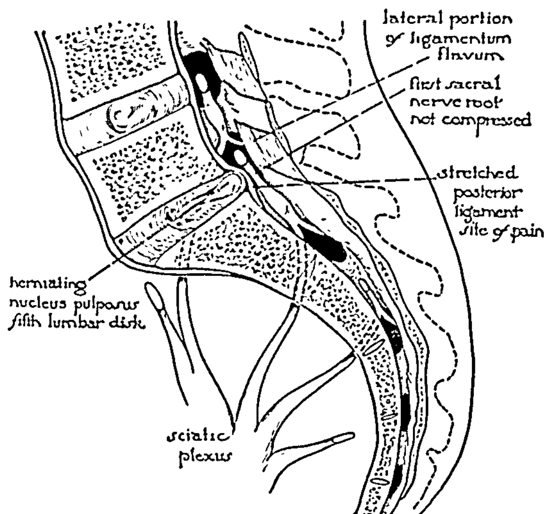


FIG. 261. Posterior displacement or slight subluxation of the nucleus pulposus of the fifth lumbar disk giving rise to low back pain without nerve root radiation. (Keegan, J. Jay. J. A. M. A. 126:868)

In addition to this characteristic posture, examination usually discloses generalized spasm of the back muscles, which are diffusely tender and without points of sharply localized tenderness. Flexion and extension of the back cause severe pain, and the rigidity of the back limits straight leg raising

Treatment. Manipulation often gives considerable relief:[16]

The manipulation is done with the patient lying on his back, both legs extended (Fig 262). The first maneuver is to flex the leg acutely on the thigh and the thigh on the abdomen, at first cautiously a few times on the least affected side, then more suddenly and forcibly. The second maneuver is forceful full extension of the leg by combined kick of the patient and pull with the operator's hand on the ankle. This procedure then is repeated on the more affected side, repeating one to ten times as seems needed by report of relief by the patient. This is noted by the ease with which the patient can extend the leg on the table or can be determined more certainly by having the patient stand, when he can walk erect and is able to bend

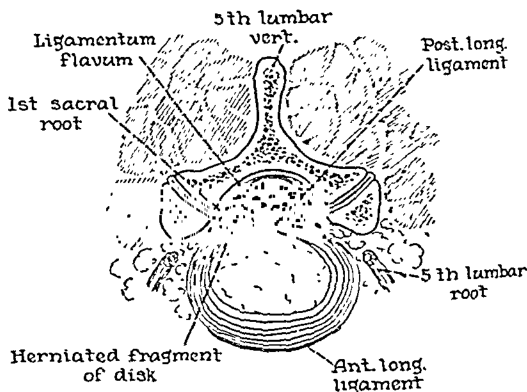


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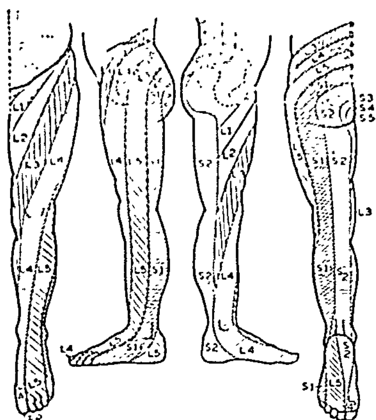


Fig. 261. Composite dermatome chart of the lower extremity determined by outlining the area of hypalgesia due to compression of a single nerve root by posterior herniation of a nucleus pulposus. (Keegan, J. Jay: Arch. Neurol. & Psychiat. 50:81)

monly involved. The posterior portion of the intervebral disk lies at the level of the intervertebral foramen through which the nerve roots pass. Posterior herniation of the nucleus, usually lateral, causes irritation or compression of the nerve root directly behind it. The onset may occur during stooping, lifting or straining, with severe "sciatic" pain in one buttock radiating down the thigh and the calf into the toes. Sneezing or coughing may aggravate it. There may first be mild or severe pain in the back with temporary reflex inhibition of movement, and the "sciatic" pain may come on later.

On examination, the back shows rigidity in slight flexion, with marked spasm of the erector spinae muscles. There is sometimes a lateral bending (sciatic scoliosis) slightly toward or away from the affected side. The affected leg may be held slightly flexed and the patient may limp. Forward bending is limited and painful, while lateral bending may be much easier. Percussion lateral to the lumbosacral junction may aggravate the pain. The knee jerk or the ankle jerk may be absent, and areas of diminished sensation, called hypalgesia, may be present in characteristic patterns in the foot, the leg and the thigh[3] (Fig. 261). The straight-leg-raising test (Fig. 247) often shows limitation of motion and aggravation of pain as compared with the normal side. A careful roentgen examination should be made to rule out both a narrowing of an intervertebral space and other lesions.

It is now recognized that many attacks of low back pain with "sciatica," even without immediate antecedent

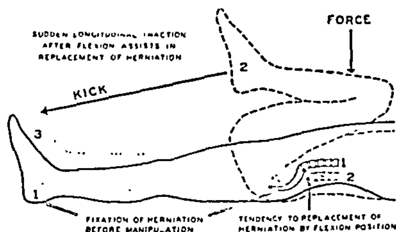


Fig 262. Manipulation for reduction of early or slight subluxation of the nucleus pulposus of a lower lumbar intervertebral disk. (Used by Dr. A. W. Abts, after Troedsson, B S.: Arch. Phys Therapy, X ray, Radium 18:10)

forward without pain No support is needed for the patient who is treated the same day of the onset of symptoms, and he may resume work The patient who is treated a few days after the onset has overlapping adhesive tape applied to the lower lumbar region and is advised against his usual activity for 3 or 4 days

Another method of manipulation is shown in Figure 263.

Posterior Herniation of the Nucleus Pulposus

Symptoms. The acute symptoms that accompany protrusion of the nucleus posteriorly through the annulus fibrosus, that is, herniation, are usually different from those described for subluxation.[3] The fourth and the fifth lumbar disks are those most com-

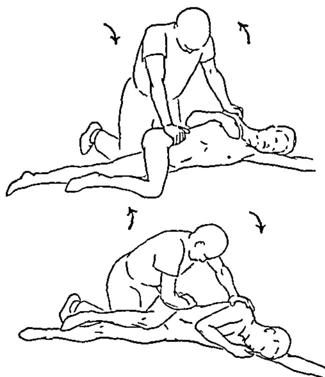


Fig. 263 Manipulation of the back. The patient lies on his side. The leg underneath is extended fully, and the other is flexed to almost a right angle at hip and knee. The surgeon rotates the pelvis forward and the trunk backward, then reverses direction for the second maneuver The patient is asked to note any painful areas during these maneuvers Frequently there is a sensation of snapping, followed by complete relief. The same maneuvers should be carried out with the patient lying on the opposite side

low and the back shows little to account for it (see p. 373).

In most cases, a roentgen examination will be indicated without undue delay.

CHRONIC MYOSITIS AND FIBROSITIS OF THE BACK

Pain in the back arises very often from lesions of the muscular and the aponeurotic tissues. Common etiologic factors, especially in cases of slow onset, are droopy posture, lack of exercise, obesity, flatfeet and, occasionally, shortness of one leg. Acute infections, exposure to cold and wet, and sleeping in a strained position or in a draft may precipitate symptoms in those already predisposed. In others, unaccustomed exertion of the back may be a factor. Chronic myositis and fibrositis may first appear as an aftermath of an acute back strain, the acute process fails to subside entirely because one of the postural factors causes a chronic strain on the injured area.

Often a number of factors operate together. In an obese individual leading a sedentary life, lack of exercise weakens the muscles that hold the spine erect, and heavy breasts or a bulging abdomen increases the load on the erector spinae (sacrospinalis) muscles. The chronic overloading also tends to cause flattening and eversion of the feet, and these in turn put a strain on the lower back.

Diagnosis. A history of slow onset of pain in the lower back or of persistent pain following injury should indicate the need for a careful search for etiologic factors. Examination often shows droopy posture with changes in the spinal curves, and often the patient walks with everted, externally rotated feet. Back flexion and extension show limitation accompanied by discomfort, but straight leg raising and extension of the thighs may be more or less normal. Palpation discloses muscle spasm and tenderness in the affected muscle groups or, more frequently, at their bony attachments.

The most commonly affected areas are in the erector spinae muscles below the twelfth rib, the lower attachment of these muscles to the lumbodorsal fascia and to the sacrum, the underlying sacral portion of the multifidus muscle, and in the medial portions of the gluteal muscle. Careful search often reveals areas of exquisite tenderness Pressure on these often reproduces the patient's pain, which may radiate up and down the back or in a segmental distribution round the body Myositis and fibrositis of the lower back may be associated with "sciatic" pain, that is, pain down the posterior or the lateral aspects of the thigh and the calf. Such pain is thought to be of reflex rather than of disk origin when no sensory disturbances and no changes in the reflexes accompany it.

TRIGGER POINTS. Steindler[20] suggests that in many cases of low back pain there are definite areas of localized pain which may be found by palpation over the lower back and the posterior ilium. These tender areas, which are associated with radiation of the pain down the leg and with faulty posture, can be identified as the trigger points from which most of the disability arises. He has attempted to establish the relation of these local points to the radiation of pain by the injection of 5 cc. of a 1 per cent solution of procaine hydrochloride. When the needle comes in contact with a trigger point, there is an aggravation of the local pain, and the radiation of pain in the leg is also

trauma, particularly if recurrent, may be due to herniation of the nucleus pulposus.

Treatment. Conservative treatment consists of rest in bed, boards being used under the mattress; heat is applied locally or hot baths are given to relieve muscle spasm; and salicylates and barbiturates are administered liberally for pain. Continuous traction may be applied to the affected leg. Any particularly tender muscles may be infiltrated with procaine solution. In mild cases associated with low back pain, the application of adhesive strapping may be helpful. In many instances, the symptoms improve or subside in a few weeks. When symptoms are persistent and severe, and when other causative lesions have been carefully excluded, a consultation with a competent neurosurgeon or orthopedist should be obtained and diagnostic roentgen study should be made. Operation for removal of the disk protrusion (or the much rarer hypertrophy of the ligamentum flavum that produces similar symptoms) often results in satisfactory relief.

Low Back Pain Due to Herniation of Fascial Fat

Acute low back pain, sometimes accompanied by leg pain, may be due to herniation of fat through the deep fascia of the back.[5,13] The herniation takes place through small openings normally present, through which small vessels and nerves pass to become superficial, or through points at which the fascia is deficient or weak. The common locations are along the edge of the sacrospinalis (erector spinae) muscles and along the crest of the ilium.

In these cases the back pain usually follows trauma, such as a strain or twisting, and is often excruciating. Spasm of the back muscles is often intense. The diagnosis may be made by finding a small mass that acts as a trigger point for pain; pressure on it brings on the typical pain. The diagnosis is confirmed by infiltrating anesthetic solution round the mass, thus producing prompt but temporary relief.[13] Excision of the mass, which can be done under local anesthesia, results in prompt relief of symptoms.

THE CHRONICALLY PAINFUL BACK

Chronic or persistent pain in the lower back often presents a rather complex diagnostic problem. Primary essentials in diagnosis are a detailed history of onset and progress and a careful physical examination. This must be particularly stressed, since often undue weight is given to minor abnormalities seen on the roentgen films which may or may not be related to the cause of the symptoms.

With the patient undressed, attention is first directed to posture, gait and visible deformity of the back, such as kyphosis, lordosis and scoliosis. The feet should be examined with the patient standing, and the levels of the iliac crests should be noted to determine a disparity in leg length. Next comes palpation for muscle spasm and tender areas, and this is followed by determining the range of motion, mainly flexion, extension and lateral bending. With the patient recumbent, palpation is repeated, and the straight-leg-raising test is made, followed by a thigh extension test. Rotation should be tested as shown in Figure 263.

Rectal and vaginal examinations should be made in most patients, but especially those in whom the pain is

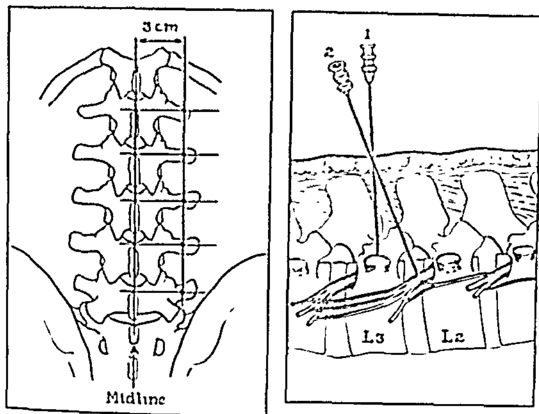


FIG. 266. Injection of the lumbar nerve roots. *(Left)* The patient lies in the prone position. A line is drawn 3 cm from the mid line, and a skin wheal is made at the level of the top of the transverse process for each root to be injected *(Right)* The needle is advanced directly downward from 1 to 7 cm. or more, depending on the amount of subcutaneous fat, until it makes contact with the transverse process. Then it is withdrawn several centimeters, directed slightly upward and inward, and advanced until the point lies from 1 to 1.5 cm. deeper *than* at its contact with the transverse process. After aspiration, to make sure that the point does not lie in a vessel, from 5 to 15 cc. of procaine solution is injected. The process is repeated for each root required.

gluteal region, extending from the crest of the ilium to the intertrochanteric area, forward from the sacroiliac joint round the lateral side of the upper thigh and the lower abdomen to the anterior abdomen, and then for a short distance on the inner side of the thigh. Pain in this area can be elicited by pressure over a point about 2 *in.* from the mid-spinous line and immediately below the last rib. This painful area corresponds to the distribution of the twelfth dorsal and the first lumbar nerves, which are involved in the irritation.

Paravertebral injections in the region of the twelfth dorsal and the first lumbar nerves are used for both the diagnosis and the treatment of this type of low back pain. For this injection the patient is placed on his abdomen in the prone position, with a pillow under the abdomen and the shoulder of the affected side raised slightly Wheals are made 3 cm. from the upper edge of the spinous proc-

produced. After the injection of procaine, there is suppression of the local tenderness and of the radiation, and the pain referred to the painful point by manipulation of the leg disappears. Steindler believes that a positive test shows that the radiation of pain is a reflex phenomenon produced by the local lesion.

The most common trigger points are as follows: (1) the sacrospinalis area mesial to the posterior-superior iliac spine; (2) the lumbosacral area over the lumbosacral junction between the spinous processes of the fifth lumbar vertebra and the first sacral vertebra; (3) the gluteal area over the origin of the gluteus maximus lateral to the most posterior portion of the iliac crest; (4) the transversosacral area at the articulation of the sacralized transverse process of the fifth lumbar vertebra; (5) the tensor fasciae latae area at the lateral border of the iliotibial band; and (6) the myofascial junction along the sacrospinalis muscle (Fig. 265).

The underlying cause of the symptoms in these areas is probably a chronic ligamentous strain, or it may be the result of a small rupture with extravasation of blood and secondary scar-tissue formation.

Judovich and Bates[17] describe a type of dorsolumbar irritation found in cases of lordosis, scoliosis and, frequently, shortening of one lower extremity with a tilt of the lumbar spine. This syndrome is characterized by an area of tenderness over the

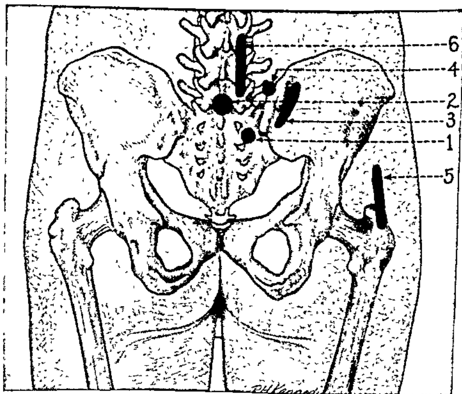


Fig. 265. Local areas of tenderness on pressure (trigger points). (Steindler, Arthur. J. Bone & Joint Surg. 22.28-34)

cent procaine being used in each area. As a rule, no more than 20 cc. is given at the first session, so that unpleasant side effects can be avoided. If tolerance to procaine is good, larger amounts may be used at subsequent visits. If tolerance is poor, the 1 per cent procaine may be diluted with an equal volume of physiologic saline solution. The needle should be introduced directly over the selected area, and should go from 1 to 3 in. beyond the deep fascia, depending on the thickness of the subcutaneous fat. As a rule, injecting only into the superficial fat is of no therapeutic value. When the needle penetrates beyond the deep fascia, the patient may note a definite exacerbation of pain; injection should be started at this point and should be finished at a somewhat deeper level. When injecting round the sacro-iliac joint and the gluteus muscle origins, the solution may be "fanned out" over a considerable area.

When pain and tenderness are present in a segmental distribution, paravertebral root injection is often of value (Fig. 266). Injection treatment should be continued at intervals of from 2 to 7 days for as long as definitely localized tender areas can be found. Often areas of diffuse, mild tenderness due to muscle spasm disappear when the more acutely tender areas subside.

EXERCISE. Exercise has been neglected as a therapeutic measure, but it is of great value, particularly in those with mild, chronic pain engaged in sedentary work and often in those who are overweight and show a droopy posture. In the absence of definite bony lesions in the roentgenograms, it is usually quite safe. Exercise serves to strengthen muscles weakened by disuse and to overcome the contracture of muscles and fascias that often has supervened. Gentle flexion, extension and lateral flexion may be started first, perhaps 5 of each 3 times daily, and gradually increased from day to day. Some patients benefit by open-air walking with the shoulders up and back, by golf, swimming, basketball throwing or light calisthenics in a gymnasium, followed by a hot bath or shower, gentle massage and a recumbent rest period. The form of exercise selected in a given case depends on the patient's age, his cardiovascular system, his inclinations and his economic status.

FORMAL PHYSICAL THERAPY. As a rule, we have discouraged the use of lamps, diathermy machines and the innumerable "gadget" treatments in these cases. However, heat and massage are of some value in easing discomfort and muscle spasm and in shortening the total duration of the disturbance. Heat is best given in the form of a hot bath before retiring, followed by gentle massage with a mild counterirritant ointment such as 10 per cent methylsalicylate in petrolatum.

MANIPULATION is sometimes of value. This should be directed principally at stretching tight muscles or fascias in flexion, extension or sidewise. Manipulation as shown in Figure 263 may also be helpful.

IMMOBILIZATION OR SUPPORT by a belt or a corset is indicated in those cases in which motion causes severe pain. The support should be discontinued gradually as pain subsides. This is best done by removing the support for short periods of exercise and then gradually increasing the periods in frequency and in duration.

Support is indicated also in flabby and obese patients until muscle tone

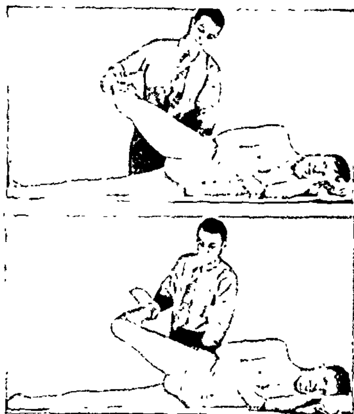


FIG. 267. Ober's test for contracture of the fascia lata. The patient is placed on his side with the pelvis perpendicular to the table. The leg underneath is extended, and the patient is steadied with the examiner's left hand over the greater trochanter; with the examiner's right hand, the leg is flexed at the knee, and the thigh is abducted and then hyperextended Gradually slipping the hand back to hold the foot, the leg is permitted to fall toward the table in the plane of the body. Contracture of the fascia lata is shown by the inability of the knee to touch the opposite leg.

esses at the level of the first and the second lumbar spines, a 3-in. 21-gauge needle being used. The needle is directed downward to impinge on the transverse process of the vertebra. It is then withdrawn slightly and reinserted upward and inward 1½ to 2 cm. further beyond the transverse process (Fig 266). The author injects procaine hydrochloride, from 5 to 15 cc. of a 1 per cent solution of procaine at each point.

These injections may have to be repeated at intervals of from 3 to 5 days, but there is no mistaking the fact that the injection does give relief of pain and relaxation of muscle spasm and is of therapeutic value long beyond the time when the anesthetic action should be effective. However, pain will continue to recur if postural or other factors are present. Flat-feet, a short leg and chronic overloading must be kept in mind in this connection.

CONTRACTURES. When symptoms have been present for a long time, actual muscular and fascial contractures may be present. These cause great restriction of motion of the back and the thighs. Ober has described a test for contracture of the fascia lata (Fig. 267)

Treatment. Many patients with chronic low back pain can be treated adequately on an ambulatory basis The methods used vary according to the causative factors in each case.

INJECTION. Tenderness and muscle spasm and localized areas of fibrositis, such as "trigger points," often show striking improvement after infiltration with procaine solution. The most localized and painful areas are injected first, from 10 to 20 cc. of 1 per

toward inward rotation. Both of these knee deviations in turn put a strain on the gluteus and the low back muscles (Fig. 269). These muscles become painful and tender, especially at their sacral ends.

Flatfeet require support, as described in Chapter 25, depending on the exact condition present in the individual case.

Shortness of one leg makes the pelvis lower on one side and causes a compensatory lateral deviation of the upper spine to the opposite side. This condition can be recognized only by measurement or fluoroscopic examination while the patient is standing. When shortness is present, it should be compensated for by raising the heel whatever height is necessary.

Foci of infection in teeth, tonsils, cervix and prostate have been suggested as a cause of persistent fibrositis. Our experience gives little support to the role of the teeth and the tonsils. Nevertheless, infection in these areas should receive attention on its own account, even though no direct connection with the back pain can be demonstrated. Infections of the cervix and the prostate often have a more tangible bearing on back pain, since they can cause referred pain in the lumbar region. These are discussed in detail below.

Bony and Other Lesions Causing Chronic Back Pain

Persistent back pain either with an acute or a gradual onset, may originate from a variety of bony or joint lesions. Spondylolisthesis, defects in the neural arches, spina bifida occulta, deformities of the spine, arthritis of the sacro-iliac joints, and primary and metastatic tumors of the spine are among the lesions to be considered. These can usually be identified by roentgen study, and they should receive the attention of the more specialized orthopedic surgeon.

It is appropriate to insert a word of caution about the interpretation of the roentgen films. Lipping of the anterior margins of the vertebral bodies and calcification of the anterior spinal ligament often form the basis for a diagnosis of "arthritis" of the spine, and minor changes about the sacro-iliac joints are often interpreted as "sacro-iliac arthritis." These changes often indicate only the deterioration and the stiffening of ligaments that accompany advancing age. We have seen many such cases in which the true origin of symptoms lay in the muscular or the fibrous tissue, caused by postural or other factors.

Chronic Backache of Uterine, Prostatic, Rectal and Pelvic Muscular Origin

Lesions of the uterus and the adnexa, such as malposition, inflammation and tumors, may cause dull, aching discomfort in the lower back. Examination of the back shows little to account for the pain, but a checkup on the history may reveal exacerbations associated with menstruation or leukorrhea, and vaginal examination may disclose significant pathologic lesions.

Prostatic inflammation or congestion sometimes causes an associated pain in the region of the lumbosacral joint and the sacrum. The pain is apt to be dull and aching and with radiation. Examination of the back shows little, but rectal examination may show a distended and tender prostate. Satisfactory relief of the back pain often follows suitable treatment of the prostatic condition.

Rectal lesions, such as cryptitis and

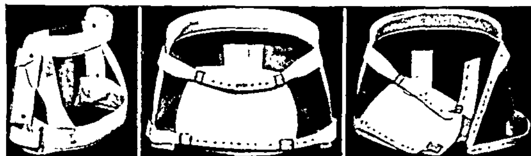


FIG. 268. A satisfactory type of low back support, especially for the patient with a heavy panniculus and a lumbar lordosis. (Compere, E. L.: West Virginia M. J. 35:105-115)

is regained and excessive weight is reduced. A suitable low back support is shown in Figure 268. Obesity may defeat any treatment program. The patient must be made to understand the role of chronic overloading of the back and the feet in the production of symptoms, and suitable treatment by diet and medication should be started at once.

Flatfeet are common in these cases When the ankles shift medially and downward, a strain falls on the medial side of the knee, so that the knee joint tends to be stretched on the medial side. In addition, there is a tendency

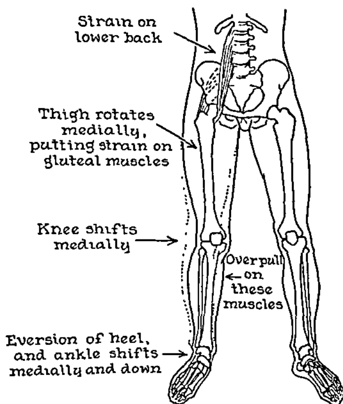


FIG. 269. The effect of flatfeet on the back. The ankles shift medially and downward. A strain falls on the medial side of the knee, so that the joint tends to be stretched on the medial side and to rotate medially This in turn puts a strain on the gluteal and the low back muscles.

brings into action the muscles attached to the coccyx.

Anatomy. It must be remembered that the coccyx is not simply a "tail bone," but that it serves as the attachment of four important muscles, the lower portion of the gluteus maximus, the coccygeus, the lower portion of the levator ani and the external sphincter ani all arise from attachment to this small bone. In addition, there is a rich nerve supply of both the spinal and the autonomic nerves in the area of the coccyx and its attached muscles.

Etiology. Although the initiating cause of coccygodynia may be trauma, the position of the pain suggests that its persistence must be due to some other lesion, perhaps a secondary trauma, such as the involvement of some of the muscles or nerve fibers in scar-tissue formation, which causes a persistent neuralgia in the region of the coccyx.

Diagnosis. The patient gives a history of definite pain in the coccygeal region, made worse by sitting on soft, upholstered chairs. Such discomfort is experienced that the patient is unable to sit still for any length of time He twists and squirms, sitting first on one tuber ischium and then on the other To obtain relief, the patient frequently places his feet underneath his chair and sits forward, holding himself upon the tuber ischium and the thighs.

On examination, there is usually tenderness on pressure over the coccyx or, more especially, along its edges. On rectal examination, no particular pain is caused by movement of the coccyx, but pain is caused by pressure of the index finger along the muscles attached to it. The roentgen examination fails to throw any light upon the cause of the symptoms.

Treatment. It is often difficult to relieve coccygodynia. In many cases, the marked pain caused by pressure along the edge of the coccyx with the finger in the rectum suggests spasm of the muscles attached to the coccyx, and relief has been obtained by daily massage of these muscles with long, sweeping strokes of the finger per rectum Local applications of heat in the form of sitz baths, hot compresses and even diathermy are of doubtful value. Certainly they do not give an immediate relief of symptoms.

Baastrup[2] has reported relief of pain by the use of roentgen rays. He applied 800 r, using a filter of 5 mm. of aluminum, and, where there was a return of pain, two more doses of 150 r. were used.

Removal of the coccyx in these cases of coccygodynia should be reserved until all conservative measures have failed In some cases in which the author removed the coccyx, he found that pain persisted.

Painful Bursae over the Coccyx

In many very thin people an adventitious bursa may develop between the coccyx and the skin. This is especially true in those few persons in whom the coccyx projects downward instead of anteriorly. A small rounded sac, tender on pressure when the patient sits down, eventually forms. This is a chronic bursitis in the adventitial bursa. Almost immediate relief is obtained by removal of the coccyx. The bursa disappears after removal of the cause of its formation.

PILONIDAL CYSTS AND SINUSES
(Sacrococcygeal Cysts and Sinuses)

Etiology. Cysts and sinuses which develop in the sacrococcygeal area are frequent lesions of surgical impor-

fissure in ano, which cause sphincter spasm, may also produce pain over the sacrum. The patient is often aware of the association. Digital and proctoscopic examination of the rectum is in order, and treatment of the anal or the rectal lesion should precede measures for the relief of the back pain.

Spasm of the perineal muscles may cause pain over the coccyx and the upper buttock with radiation down the thigh.[21]

LESIONS OF THE COCCYX

Etiology. Pain in the region of the coccyx *most often arises as a result of* trauma. Because of the fact that the tuber ischii are separated somewhat more in females than in males, the coccyx is less protected and more often traumatized in females. The trauma producing this local injury may be a fall on the back: more often some projecting object is struck in the fall, as, for instance, a stair or a child's block; or it may be the result of a kick. In such instances, the coccyx is driven forward and, if the force is sufficient, dislocation or fracture may result. Another perhaps less frequent cause of pain in this region is injury to a fixed coccyx by internal forces, especially the pressure of the child's head *on the coccyx during childbirth.*

Dislocations and Fractures

Diagnosis. Injuries to the coccyx, either through dislocation or fracture, cause acute pain in this area which is noted especially on sitting, on rising from the sitting position and on walking. It is less noticeable when the patient is lying down.

On examination, there is tenderness over the area of the coccyx, especially on pressure. If the finger is inserted into the anal canal so that the coccyx can be grasped between the thumb and the forefinger, there is marked tenderness on pressure between the fingers and on movement of the coccyx.

Treatment. In cases of dislocation, *the displacement may be palpated* in this manner, and a reduction may be effected by gentle manipulation, often with complete and almost immediate relief of pain. In cases of fracture, however, little can be done in the way of a reduction, and there is no known method of fixation.

The accepted treatment in cases of *injury to the coccyx is rest in bed* with applications of heat. Sometimes 3 or 4 weeks of this therapy is necessary before pain is completely relieved. As a rule, however, pain disappears before this if acute trauma is its sole cause.

In some cases of fracture with fragmentation, persistent pain makes the removal of the coccyx necessary. This may be accomplished through a midline incision, the sacrococcygeal ligaments being divided and the coccyx being removed by rotating it downward and away from the rectum. The operation may be performed under local anesthesia and the wound closed with interrupted sutures or packed with gauze and allowed to heal by granulation. This procedure may occasionally be performed in the office, but for most patients hospitalization is preferable.

Coccygodynia

Symptoms. Coccygodynia is a term applied to a throbbing, aching or stabbing pain occurring in the region of the coccyx. It occurs spontaneously but is aggravated by any movement, such as walking, sitting down, getting up from a chair, or defecation, which



FIG. 270 (*Left*). Pilonidal cyst with secondary sinus opening.

FIG. 271 (*Right*). Pilonidal cyst following incision and drainage of an abscess. The incision is seen above the mid line sinus opening. The inflammatory reaction has subsided, and the cyst now is ready for excision

charge sufficient to keep the skin moist and sometimes macerated. Less commonly, there are no openings on the skin, but simply the development of a mass in the mid-line over the lower sacrum. As a rule, the sinuses are not noted by the patient until early adult life, and the first symptoms are the presence of moisture, maceration, itching and sometimes burning in the region of the sinuses

The common complaint and the usual reason for treatment is secondary infection of a pilonidal cyst. Most often, this follows mild and repeated trauma, such as sitting on hard benches. The infection may be relatively mild in nature and subside spontaneously by the drainage of pus from the tract for a few days. Often, secondary fistulous openings appear, usually at one or the other side of the mid-line. These secondary fistulas may be numerous and may be some distance away from the original cyst opening (Fig. 270).

When infection produces an abscess, a red tender swelling appears in the mid line over the lower sacrum. The patient complains of marked pain and tenderness, and, on examination, the abscess is easily demonstrable Frequently, pus appears at the sinus openings or following the removal of hairs which protrude from one of the sinus tracts.

Treatment. The treatment of pilonidal sinuses must be divided into treatment of the acutely infected pilonidal cyst or sinus and the treatment of a quiescent sinus or cyst.

INCISION AND DRAINAGE. When an acute infection appears in a pilonidal cyst, it is unwise to attempt to do anything more than drain the purulent material and to permit the acute inflammation to subside. It is inadvisable to attempt any radical extirpation of the cyst or the sinus at this time because of the marked cellulitis, edema and inflammation of the surrounding tissues and because of the large area of tissue which must be excised and cannot be closed by suture.

The treatment of an acute inflam-

tance The origin of these cysts has not been well established, despite much embryologic and pathologic researches. Two theories of their development are prominent in the literature Fox,[10] by embryologic studies, has attempted to establish the thesis that these cysts and sinuses result from invagination of ectoderm in the sacrococcygeal area Gage,[11] on the other hand, believes that they are due to a maldevelopment of the caudal end of the medullary canal. He has pointed out that, in the normally developing embryo, the end of the canal, which is in juxtaposition with the skin, forms epithelium-lined sacs. Under normal conditions, these sacs disappear by involution and atrophy at term, or soon after birth, but failure to obliterate and the persistence of these vestigial epithelial sacs result in the formation of cysts and sinuses with epithelial linings in the coccygeal region.

The evidence that pilonidal cysts arise from developmental subcutaneous implants of epithelium is difficult of acceptance for many reasons Except at the sinus from which hairs protrude, no epithelium can be demonstrated in the resected cyst.[9,12] The walls of the cyst are made up of chronic granulation tissue. In cases in which an abscess is the primary lesion and no sinus is present, no epithelium can be found below the skin surface. The fact that hair may be found in dermoid cysts made it seem possible that the hair found in pilonidal cysts grew from hair follicles of embryologically displaced epithelium lining the cyst cavity. The evidence at hand makes this concept untenable. None of the hairs is attached,[9,12,17] no hair follicles are demonstrated in the cyst wall from which they could grow If the hairs are examined, the root is found protruding from the sinus or pointing toward the sinus. As early as 1851, Warren[22] described the hairs as "inverted." It is evident, therefore, that the hairs of a pilonidal cyst do not arise from the cyst wall, but enter the sinus from without.

The fact that hair from without may produce a hair-containing subcutaneous sinus or cyst seems apparent in the light of present knowledge. Interdigital pilonidal sinuses[6,8,18] are found in barbers' hands. These sinuses appear in an area where there are no hair follicles and contain short pieces of hair from male hair cuttings. The pathologic lesion, cutaneous dimple, sinus, cyst, appears to be identical with that noted in the postanal area.[14]

It must be concluded that the usual pilonidal cyst in the sacrococcygeal area is not developmental in origin due to the presence of hair-producing epithelium lining the cyst. On the contrary, the evidence points to the fact that the lesion is primarily a typical foreign body (hair) granuloma. The probable course of events is as follows:

A congenital sacrococcygeal dimple may be present in some cases; in others, no dimple is found. Poor hygiene, sweat and trauma (sitting on hard surfaces) force desquamated hairs that collect in the intergluteal cleft to penetrate the skin and set up a foreign-body reaction which eventually becomes secondarily infected

Clinical Manifestations. Whatever the true etiology of these cysts and sinuses, the clinical symptoms are constant. In almost all cases, there are from one to several tiny openings in the mid-line of the intergluteal cleft over the lower portion of the sacrum. Hairs often protrude from these openings, and there is frequently a dis

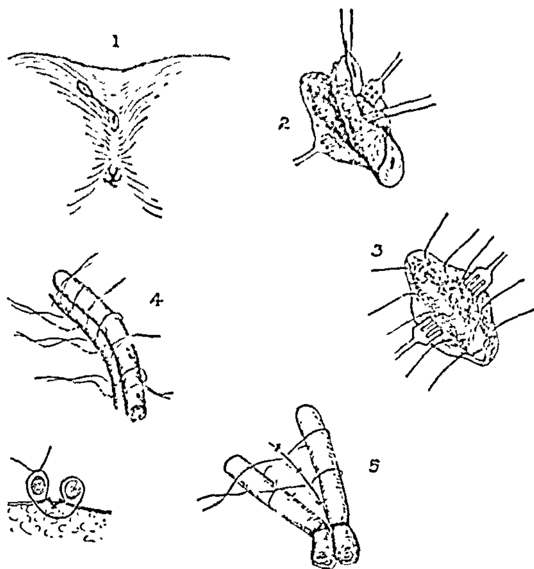


FIG. 272. Technic of excision of a pilonidal cyst The patient is placed on the abdomen with a pillow under the hips. The area round the cyst tract is infiltrated with procaine solution. (1) Line of incision to include any accessory openings and mid-line opening. (2) The cyst and the sinus are excised as a narrow tract with a scalpel. It is important to keep the edges of the wound on tension with sharp rake retractors. (3) The dead space is obliterated with buried sutures of fine silk or catgut, all of which are placed before any are tied (4 and 5) Method of wound closure with mattress sutures tied over gauze rolls and interrupted sutures between the mattress sutures. All the skin sutures are of steel wire

After removal of the cyst and the sinus, a clean wound remains, with normal fatty tissue on the sides and sacral fascia in the base of the wound. Closure is effected in 2 layers. The first layer is of fine alloy steel wire or fine silk, 4 or 5 interrupted sutures placed so as to include the fatty tissue on each side of the wound and the sacral fascia at its base. These sutures are all inserted before any are tied, because the approximation of the

mation, therefore, consists of drainage of the purulent material and the application of hot moist dressings. In a few cases, drainage may be accomplished by simple dilatation of one of the sinus openings. Frequently, however, it is wise to incise the cyst. This can be accomplished under local infiltration anesthesia in the ambulatory patient. The anesthetic solution is injected intradermally in the line of the proposed incision. Towel clips are used, as described under the section on incision of abscesses (Fig 22), to prevent pain. If a suction apparatus is available, the pus in the abscess cavity may be aspirated without discomfort. All hairs in the abscess cavity should be removed carefully before gauze packing is inserted. Antibiotic therapy appears to aid in controlling the infection, although the inflammatory process will subside promptly without it if adequate drainage is provided.

The usual treatment by hot wet dressings, with removal of the packing in from 2 to 3 days, permits subsidence of the infection and of the inflammatory reaction. After removal of the packing at the first dressing, the wound is searched for hair collections or deep pockets. The hairs are removed with forceps. The lips of the wound are kept apart with gauze until the wound cavity begins to fill with granulations. If these appear unhealthy, they may be cut down by applying Carnoy's solution (p. 17) on a cotton swab. The wounds are allowed to heal and no further surgery is attempted in such cases for a period of from 2 to 3 months at least. In a very few cases, recurrence will not take place following simple incision. This is especially true if the incision has been wide and adequate drainage has been obtained. More commonly, however, recurrence can be expected, unless excision of the sinus tract is performed.

Peterson and Ames[19] believe that recurrence can be prevented and permanent healing achieved, even in acute cases, by suturing the cyst wall to the skin. After wide incision of the abscess, they excise a wedge-shaped section of tissue between the skin and the cyst wall and unite these 2 structures with a running suture of wire or silk. This is a slight modification of the marsupialization procedure long practiced by Buie.[4]

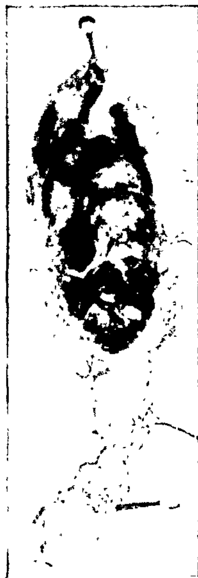
Excision and Primary Suture. In the healed pilonidal sinus following incision for acute infection, or in the chronic draining pilonidal sinus without marked inflammatory reaction (Fig. 271), excision of the tract and primary suture of the wound are the method of treatment which has given the best result in the hands of the author.

The technic of the operation is simple. A wall of procaine-epinephrine is injected by infiltration round and under the sinus tract and cyst. The incision is then begun in the mid-line over the sinus tract and continued downward to surround the sinus opening. With sharp rakes as retractors, the incision is deepened to isolate the sinus opening entirely. An Allis forceps is then applied to close the sinus orifice and to serve as a tractor on the tissue to be removed. With the tissue constantly on tension, the dissection is then carried upward, the sinus and the cyst being surrounded. The line of separation from fascia overlying the sacrum is easily recognized, but the lateral separation must be made by the scalpel. When there are secondary sinus openings, these are dissected out before the main cyst is attacked.



FIG. 273 (*Top, left*) Pilonidal cyst with lateral sinus opening. (*Top, center*) Result 12 days after excision of cyst. All dressings have been removed and the patient is well (Ferguson, L. Kraeer and Mecray, Paul M., Jr. Am. J. Surg. 36:270-278)

FIG. 274 (*Right*). Pilonidal sinus and cyst excised under local anesthesia in an ambulatory patient.



Cutler and Zollinger[7] reported on the use of a modified Carnoy's solution. After incision and drainage of the infected tract, a packing is inserted and allowed to remain in place for 3 days. When this pack is removed, the edges of the wound are protected with petrolatum or zinc oxide ointment and the wound is filled with Carnoy's solution, which is allowed to remain in place for from 5 to 10 minutes. The entire inside of the wound becomes tanned, and this removes the chronic granulation tissue and any remnants of epithelial tissue which may line the cavity. The excess Carnoy's solution is sponged away and some gauze packing is placed in the wound. This dressing is replaced in 3 or 4 days. At the next dressing, the tissue destroyed by the Carnoy's solution comes away with the packing. If the granulations are not healthy, Carnoy's solution is reapplied. The wound should be inspected carefully for loose hairs, which should be removed with forceps. The wound must be kept packed to keep down the granulations. As healing takes place, the granulations gradually fill the wound and epithelization occurs.

Most of the patients with pilonidal cyst are of the fat, hairy type. The hairs on each side of the gluteal cleft often grow downward and act as a bristle brush on the fresh scar tissue of the healed pilonidal wound. If this healed scar is not protected, it is often traumatized by the hairs on each side of the wound and a new ulceration appears. To avoid this complication,

wound obtained by tying them as they are inserted makes it difficult and even impossible to insert accurately the last 2 sutures. This layer of sutures obliterates dead space in the base of the wound. The skin is approximated and dead space is further obliterated by the use of mattress sutures of alloy steel wire tied over gauze rolls (Fig. 272). Often these wire mattress sutures are placed first so that the deepest portion includes all the layers of the wound, including the sacral fascia. The superficial portion of the mattress is not placed until the buried fine wire sutures have been introduced and tied. Usually, several interrupted sutures of fine wire are used to aid in the further approximation of the skin edges. A pyramidal-shaped pressure dressing of gauze is applied and held in place with firm adhesive strips.

When primary closure cannot be effected without too much tension, the skin edge is sewn to the sacral fascia or to the base of the cyst, as recommended by Buie.[4]

Our experience has shown that primary union is dependent on the obliteration of dead space and the prevention of serum collections, and, to this end, pressure on the wound is further obtained by placing the patient on his back on a litter or an operating table for an hour after operation. He is then permitted to go home. Our patients are usually given three 1/6-gr. tablets of morphine sulfate to be taken by mouth every third hour if necessary. As a rule, they are not used, most patients experience more discomfort from the adhesive strapping than from the operative wound. Usually, 300,000 units of long-acting penicillin is given prophylactically and repeated at each dressing.

Dressings are inspected on the third day, and, at this time, the interrupted sutures in the skin may be removed. These wounds are prone to become moist and macerated, and the skin round the sutures frequently becomes infected. Often at this stage one notes a redness and an induration of the wound, but these subside readily. Gauze moistened in 70 per cent alcohol solution has proven to be a most satisfactory dressing. On the sixth day, the wire mattress sutures are removed and another alcohol dressing is applied. The wound is kept under observation for another week. Occasionally, there are small serum collections in the wounds; usually, these do not appear until after the mattress sutures are removed, and in many instances drainage of the serum will take place through the stitch holes. These wounds are treated with alcohol dressings and are opened reluctantly, and only if spontaneous drainage does not occur. If there as a tendency to maceration of the skin about the wound, zinc oxide ointment is of value.

This method of therapy by excision under local anesthesia of the pilonidal cysts and sinuses in the quiescent stage in ambulatory patients has produced a cure in 92 per cent of our cases with few recurrences (Fig. 273). The healing period, averaging 17.4 days in 37 patients, has been a factor in support of this treatment. The literature, however, gives numerous other methods.

Sclerosing Therapy. The treatment of pilonidal cysts and fistulas by sclerosing solutions has come to attention during recent years. The rationale of this therapy is similar to that of excision, in that the sclerosing solution produces a destruction of the tissue lining the cysts and the sinuses which permits normal granulation to obliterate the tract.

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it is necessary to keep the hairs away from the healed wound. The author has tried many ways to do this. Repeated shaving round the wound does not seem to be the answer, because, as the stubble grows out, the hairs again dig into the fresh scar. Inch-wide adhesive strips on each side of the wound, applied even before healing takes place, control the hairs on the side of the wound and tend to catch loose hairs which otherwise find their way into the granulating wound in the intergluteal cleft.

The author is convinced that recurrence in pilonidal cysts treated by excision and packing is not due to incomplete removal of the cyst but rather to hairs collecting in the moist wound in the intergluteal cleft. There is thus produced a wound filled with chronic infected granulations due largely to the collection of hair which acts as a foreign body. It is in this type of case that Carnoy's solution, packing and adhesive strips round the wound give good results.

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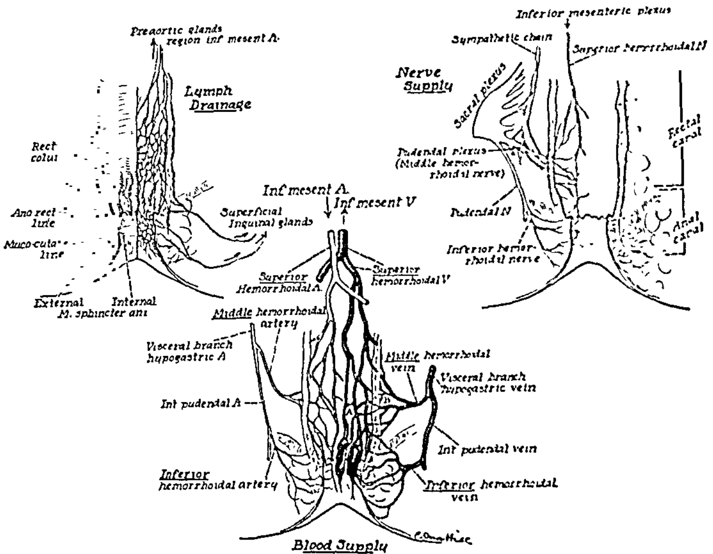


Fig. 275. Anatomy of the anal canal and the lower rectum.

▪ 20 ▪

Perianal Region, Anus and Anal Canal

ANATOMY

In order to understand the pathogenesis and the treatment of many of the diseases of the anal region, a clear understanding of the anatomy of the part is required. The postallantoic gut grows downward to meet the invagination of the epiblast at about the third month of fetal life. The loose mesoblastic tissue is pushed aside to form the anal canal Eventually, the anal membrane, lined by endodermic cells and covered by ectodermic epithelium, is absorbed to make the rectum and the anal canal a continuous tube. This junction of endoderm and ectoderm is seen in the anal canal at the pectinate line, where the mucous membrane of the rectum becomes continuous with the invaginated skin of the anus. Surrounding this epithelium-lined canal are two sets of sphincter muscles The upper, or internal, sphincter is a continuation of the circular muscle of the rectum and is an involuntary muscle under the control of the autonomic nerves. The external sphincter lies just under the skin and the subcutaneous tissue; it arises from the tip of the coccyx and passes forward to encircle the anal canal and to lie inserted in the central tendon of the perineum. The muscle is a true sphincter, some of the medial fibers completely encircling the anal canal. (Fig. 275)

These two sphincter muscles, especially the external sphincter, pull the anal canal together after the manner of a purse string, thus producing a puckering effect upon the lining membrane of the canal. The mucosa is thus thrown into folds known as the columns of Morgagni, and between the folds pockets known as crypts of Morgagni are formed. These end distally at the pectinate line, where the mucous membrane becomes continuous with the pavement epithelium of the skin. The skin edge is also thrown into folds, and the overlapping margin contains projections which are called papillae.

The pectinate line is an important landmark because it separates structures of endodermic from those of ectodermic origin. The arterial supply of the endodermic tissue is from the inferior mesenteric artery via the superior hemorrhoidal artery and from the hypogastric artery via the middle hemorrhoidal artery. The veins of the endodermic portion of the anal canal drain into the portal circulation, but those of the ectodermic tissue drain into the inferior vena cava The nerves of the endodermic tissue are autonomic and are, therefore, not subject to ordinary stimuli. Those of the ectoderm, including the papillae and the external sphincter, are cerebrospinal, ordinary motor and sensory nerves. The lym-

Protrusion at the anus is a symptom to be looked for and, if this is present, inquiry should be made as to whether the protruded mass disappears after the stool and if it appears only with defecation or spontaneously, due to straining.

Itching is a symptom which indicates perianal or anal irritation.

Finally, and most important, inquiry should be made about the bowel habits of the patient, whether there has been any change in the character and the number of the bowel movements, any increase in the amount of cathartics necessary, or any abdominal pain associated with them.

With this information at hand, one may obtain a fair idea as to the nature of the lesion and as to its location in the anus or higher up in the rectum.

Examination of the Patient. No matter how much information may be obtained from the history of a patient suffering from an anal lesion, a diagnosis cannot be made without a thorough examination. The diagnosis of anal lesions across the office desk is inexcusable negligence, because the examination is one which can easily be performed in any office. (Fig. 276) If a thorough examination is to be made, the patient should cleanse the lower bowel with a saline or a soap-

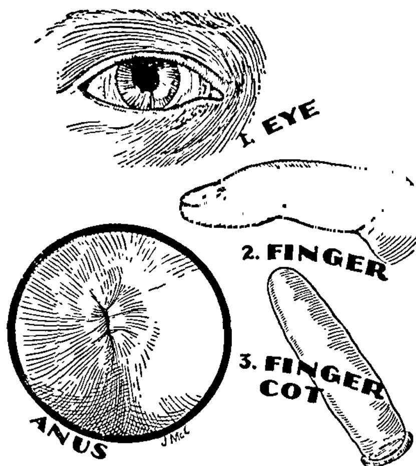


Fig. 276. Requirements for anal examination

phatics of the endodermic portions of the anal canal drain into the retroperitoneal nodes along the rectum and the anterior wall of the sacrum. Those below the pectinate line drain upward across the perineum to the inguinal nodes (Fig. 275)

These anatomic points have important bearings upon the pathogenesis, the symptoms and the treatment of anal diseases. The crypts of Morgagni often become the seat of infections, and, because of their deep situation overhung by the anal papillae, the infection tends to burrow rather than to drain spontaneously. Inflammation and injury of the mucous membrane above the pectinate line are not painful, but, when the process involves the papillae or other parts below the pectinate line, pain often becomes a prominent symptom. The drainage of the superior and the middle hemorrhoidal veins is into the portal circulation, hence the ever-present possibility of liver abscess by an extension of or embolus from thrombosis of these veins, though this rarely occurs. This danger of embolism to the portal vein is almost never present from thrombosed external hemorrhoids, although an anastomotic network joins the superior and the inferior hemorrhoidal veins.

The drainage of lymph from the anal region to the inguinal nodes accounts for the not-infrequent inguinal adenitis associated with perianal infections.

DIAGNOSIS OF LESIONS OF THE LOWER RECTUM AND THE ANUS

Symptoms. To treat lesions of the lower rectum and the anal region intelligently, an accurate diagnosis is important. This can be made only if an adequate history is obtained from the patient and a careful examination of the involved area is made. In taking the history of a patient complaining of anal difficulties, six chief symptoms are of significance and inquiry should be made about them.

The most important of these is bleeding. The appearance of bright blood in the stools signifies an ulceration or trauma to the lower bowel or the anus. It is important to know whether the amount is large or small, whether the blood is mixed with the stool or appears after it, whether the bleeding is in clots and whether it is bright red or dark in color.

The second symptom to be inquired about is pain. It is important to know whether the pain is constant or appears only with bowel movement. More often, constant pain signifies an inflammatory lesion, whereas pain which appears with the stool indicates a lesion that is traumatized by defecation. To know the type of pain—whether it is sharp or dragging, and its duration after a stool—is helpful in arriving at the diagnosis. Nearly always pain signifies a lesion of the ectodermal portion of the anal canal, that is, that area supplied by somatic nerves. Even lesions above the pectinate line, such as strangulated internal hemorrhoids, probably produce pain because of the associated edema and inflammatory reaction that appears in the adjacent skin (ectodermal) tissue distal to the pectinate line.

Discharge is another symptom which is significant. The patient should be asked whether the discharge is constant, necessitating the wearing of a pad, its type and character, whether it is bloody, mucoid or purulent, and whether there is any associated pain.

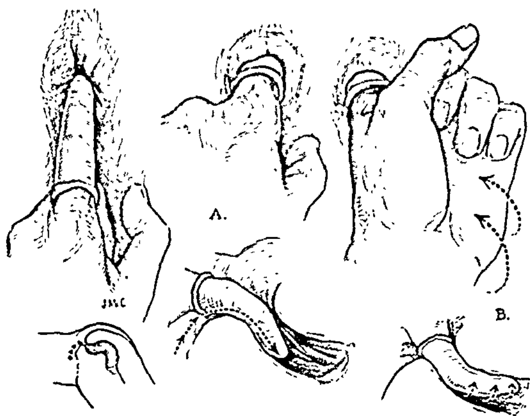


FIG. 278. Digital examination of the anal canal and the lower rectum. The finger is not inserted abruptly into the anal canal. With the glove or the finger cot well lubricated, the ball of the finger is placed at the anal canal and pushed downward along the anterior wall After palpating this area (A), the hand is turned so that the finger sweeps round the anal canal (B). If gentleness is employed in this examination, no pain is experienced by the patient.

fingers. The digital examination (Fig. 278) of the anal canal and the lower rectum is performed with the finger covered with a glove or a finger cot well lubricated. The finger should be inserted into the anal canal with the rounded part at the anal orifice; it is then pressed downward along the anterior anal wall until it is inserted past the sphincter muscles into the rectum If there are painful lesions of this area, the finger should be introduced against the opposite anal wall; in this way, pressure is avoided and pain is reduced to a minimum. Examination should include, first, the region of the anal canal; the finger can then be advanced to palpate the rectum, the coccyx and, in male patients, the prostate. Palpation of the higher areas of the rectum is carried out first with the hand directed so that the palm is anterior, then with the hand turned over so that the palm is posterior. Two points to be looked for in palpation of the anal canal and the lower rectum are, first, the presence of areas which are tender on pressure and, second, the presence of masses.

After a thorough inspection and palpation, instrumental examination is made, first of the anal canal and then of the lower rectum. Examina-



FIG. 277. (*Left*) Lateral, or Sims's, position for examination of the anal region and the lower rectum (*Center*) Knee-chest position for examination of the anal canal and the lower rectum. (*Right*) Position on the proctoscopic table for examination of the anal canal and the lower rectum.

suds enema at least 2 hours before presenting himself at the office. Inspection of the anal canal is possible without preparation, but, since an adequate examination usually includes inspection of the lower bowel through the proctoscope, enema preparation is imperative.

THE POSITION OF THE PATIENT. To make an examination of the anal region, one of three positions may be used. For older people and pregnant women, the most satisfactory one is probably the lateral, or Sims's, position (Fig. 277, *left*). The patient lies on the left side with the left leg extended, the right knee is flexed and the patient is draped to expose the anal region. The examiner sits at the side of the examining table.

The knee-chest position is perhaps a more convenient one (Fig. 277, *center*) for examination and proctoscopy. The thighs should be perpendicular to the table, the feet extending over the end of the table; the knees should be spread apart, the side of the face placed on a pillow on the table, and the trunk at an angle of about 15° to the table. This is the only position for the examination of children. It is a difficult position for older patients, and, for that reason, the lateral position is more often used in examining them.

The most satisfactory position for examination and treatment of anal lesions is that obtained on the proctoscopic table (Fig. 277, *right*). In this position, the patient leans over the table, which is tilted so that the buttocks and the anal region are easily visualized.

The examination of the patient should be carried out in an orderly manner: First, inspection of the anal orifice and the perianal region; second, digital examination of the anal canal and the lower rectum; and, third, examination with anoscope and proctoscope of the anal canal, the rectum and the sigmoid. The inspection of the anal orifice and the perianal region is best done by spreading the buttocks apart, small pieces of gauze being used to hold the skin under the

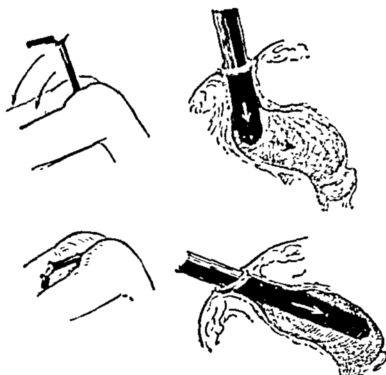


FIG. 280. Insertion of the proctoscope. When the patient is in the inverted position, the well lubricated scope is inserted into the anal canal in an almost vertical direction. After having passed through the anal canal, the outer end of the scope is carried toward the patient's feet to direct the tip along the lower rectum.

At times, after a thorough examination of the rectum and the anus, no cause for the patient's symptoms is found. The fact must not be overlooked that adjacent organs may be pressing upon the rectum, thus causing symptoms referred to that area. For this reason, a *pelvic examination* is important, especially in female patients, in whom rectal pain and discomfort may be due to the pressure of a myoma or a retroflexed uterus.

CONDYLOMA ACUMINATUM (ANAL WARTS, VENEREAL WARTS, ANAL PAPILLOMAS, ANAL VERRUCAE)

Anal warts (Fig. 281) appear in the perianal skin and in the skin of the anal canal up to the dentate line. They arise from the papillary layer of the skin and consist of a connective-tissue stalk containing blood vessels covered with stratified squamous epithelium. There are two chief varieties: one type appears as the usual verruca vulgaris, a wartlike growth in the perianal skin, the other, and more common, type is often spoken of as "venereal" warts, although there is no relationship between them and venereal disease.

Etiology and Diagnosis. These warts are caused by irritating discharges and *may be found associated with hemorrhoids*, proctitis, colitis and, occasionally, with fistulas; in females, they may be due to leukorrhea. They appear as pointed, cauliflowerlike growths which frequently surround the anal orifice and may extend upward in the anal canal. Usually, they are small, but they may attain a very large size. The warts are soft, pale in color and bleed easily when traumatized. They may be distinguished from epithelioma of this area by the fact that there is no induration at the base and no ulceration on the surface.

Symptoms. These growths cause considerable irritation of the anal area, often with itching, and, because it is difficult to cleanse them, moisture and

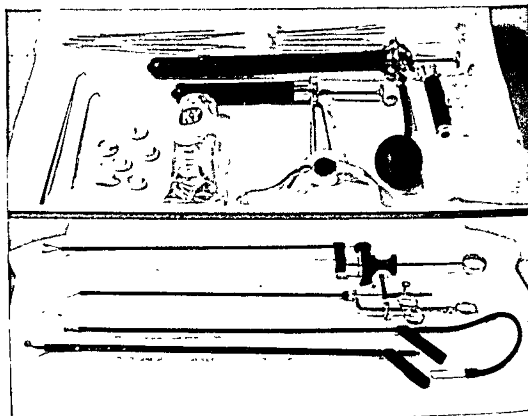


FIG. 279. (*Top*) Tray for anal and rectal examinations The tray contains hooked probes, finger cots, lubricant, lighted anoscope and proctoscope, waste cotton and cotton swabs 16 in and 8 in long. (*Bottom*) Accessory instruments frequently used biopsy forceps, electrosnare and suction electrodes with straight and curved tips

tion of the anal canal is best made with a lighted anoscope, which may be open at its end or at the side. In its introduction, there must be due regard for painful lesions of the anal canal, and the well-lubricated anoscope should be passed along the anal wall away from the painful lesions. The anoscope permits inspection of the structures of the anal canal, and, with a curved hook, a further examination may be made of the crypts, which are the usual sites of origin of many anal lesions.

All the foregoing examinations may be made without any particular preparation of the patient and without anesthesia. (Fig. 279)

To complete the examination, a proctosigmoidoscopy should be performed. This entails insertion of a lighted tube through the rectum and the rectosigmoid for inspection of the wall of the lower bowel. (Fig 280) For this examination, the bowel must be free of fecal material. Occasionally, it is possible to make the examination without previous preparation, but, as a rule, the bowel should be emptied 3 or 4 hours before by a cleansing enema. Proctosigmoidoscopy is facilitated considerably by the use of an aspirator (Fig. 13) to remove liquid fecal material and mucus. In addition, long cotton swabs should be at hand for cleansing as necessary.

small cysts. They are often seen in considerable numbers, being about the size of the head of a pin. The duct orifice usually is dilated, and, as a rule, the sebaceous material may be expressed without difficulty. Occasionally, they form true cysts; these may become infected and be mistakenly diagnosed as a perianal abscess.

Treatment. Sebaceous cysts in this area are treated in the same manner as are cysts in other locations on the body (p. 179). It is better to leave the wounds open and permit healing by secondary intention than to attempt to suture them.

PRURITUS ANI

Itching of the perianal region and of the anal orifice is one of the most troublesome conditions a physician is called upon to treat. This symptom complex, which is described as pruritus ani, is not an uncommon one; it appears more frequently in men than in women, and perhaps is seen more often in those who are blond and in those who are obese. It is rarely a symptom in the Negro race. It is found most often in those between 20 and 50 years of age. Buie[3] reports that 96 per cent of the patients at the Mayo Clinic were over 30 years of age.

Symptoms. Itching usually begins in a relatively mild form, and the patient tries various proprietary and home remedies in an effort to obtain relief. Lack of success with this therapy may result in more vigorous efforts to obtain relief by the use of anesthetic ointments or other forms of local application. As a rule, the itching appears first at night and following bowel movements; as time goes on, however, it persists both day and night. Sleeplessness and worry add to the patient's irritability and increase the severity and the prominence of the local symptoms, so that a vicious cycle is established and the distressing symptoms become almost intolerable.

Etiology. In spite of a very voluminous literature on the subject, the cause of pruritus ani has never been well established.[16] However, several facts are known about its etiology and are helpful in the treatment of the symptom complex. Itching is believed to be a subpain sensation; it travels over the same nerve paths which transmit pain. The impulses of itching arise in the epidermis, and the itching is absent when the epidermis is removed or destroyed. Scratching increases the itching. With these facts in mind, it can easily be seen how minor lesions of the anal canal or the anal orifice, such as hypertrophied papillae, sentinel piles, skin tabs (Fig. 282) or cryptitis with edema of the adjacent papillae, all serve as sites of an original irritation which can be increased and spread by scratching. For this reason, lesions of the anal canal may be looked up as trigger points for the initiation of the original irritation which began the pruritus.

Many believe that in every case some local pathologic process of the anal canal or the perianal region may be found which will explain the origin of the itching.

Others explain the perianal itching as being due to moisture in the perianal region between the buttocks: they say that there is a predisposition in this area, because of its situation which prevents evaporation, especially in those who are obese, to the development of intertrigo, with maceration and irritation followed by itching. The same chain of events may occur from discharges of pus, as in fistula in



Fig. 281 Several varieties of anal warts (condyloma acuminatum).

excoriation of the perianal skin usually are present. Bleeding may be a symptom and pain appears, especially if there is an associated anal lesion such as a fissure.

Treatment. The treatment of anal condylomas by irradiation has not been too successful, and their removal by electrocoagulation under local anesthesia has been a tedious, time-consuming and not always adequate process. Kaplan[7] and Culp[4] have suggested the local application of a 25 per cent suspension of podophyllin in mineral oil to the condylomas. A marked local reaction is produced with some edema and inflammatory change in the tissues at the site of application. The condylomas blanch and slough off on the second and the third days after application of the podophyllin, and on the fourth or the fifth day the tissues return to normal without ulceration or scarring.

Usually, the process is painless, but occasionally, if the podophyllin is applied too generously, some sedation may be necessary. If recurrences or new growths appear, they may be treated in the same way. At least a week should be allowed for recovery from one application before another is given.

Condyloma Latum

Flat condylomas, which are relatively infrequent, are manifestations of secondary syphilis. Usually, they appear on the perianal skin and often involve the anterior perineum, vulva and scrotum. They are flat, oval or rounded patches, pearly white in color, which multiply and often form fungating masses. The edges are sharply defined. They usually cause few symptoms. When they are seen, a diagnosis may be made by a serologic examination. The usual systemic treatment for syphilis will produce a cure. This is the only type of condyloma which is truly venereal.

Sebaceous Cysts

There are numerous sebaceous glands in the region of the anal opening, and not infrequently these form

tients in whom there appears to be no demonstrable etiologic factor. These usually are the patients with the most severe pruritus and are, therefore, the most difficult to treat. Hayden[6] makes the somewhat discouraging observation that "the worse the appearance of the perianal skin, the less likelihood there is of finding within the anal canal a pathological condition which can, by any stretch of the imagination, be considered the cause." The inability to find a local cause and the fact that the itching may follow the ingestion of certain foods have suggested an allergic base for the itching. Tobacco, alcohol and caffeine are other substances which may bring it on. That there is a marked neurogenic factor in the production of pruritus is shown by the fact that during periods of stress and strain many patients suffer an exacerbation of their itching or have a recurrence of it.

On examining the patient complaining of pruritus, one may find several types of local pathology, depending upon the duration and the severity of the disease. In the milder types, one may be fortunate enough to find a single edematous skin tab or an anterior median raphe which is the local seat of the itching. More commonly, however, the skin round the perianal region appears to be thickened and is grayish pink in color. The normal radiating folds of the skin at the anal orifice are thickened into rugae, between which may be found deep sulci containing shallow linear ulcers. At times the surface of the skin is thick and sodden. Most commonly, the linear ulcerations are seen in the gluteal fold in the posterior mid-line, although they may radiate in all directions from the anal orifice. Less commonly, either with or without a previous pruritus, there is an acute process characterized by intense redness of the perianal tissues, often with bleb formation. The process in this stage usually extends forward along the anterior perineum, in females to the vulva and in males to the scrotum. The skin is evidently edematous and the process is one of an acute dermatitis. In other instances, the skin may be thin and shiny, evidently atrophic; this is looked upon as one of the later stages of the disease.

Treatment. The treatment of any disease with such an ill-defined etiology as pruritus is at once difficult and unsatisfactory. A careful history may disclose a relationship of itching to fatigue or nervous upsets, or to the use of alcohol, coffee or tobacco. These may be leads of value in suggesting therapy. Local lesions of the anal canal and the lower rectum should be carefully sought and eradicated. Local anal deformities such as sentinel piles, fissures, hypertrophic skin tabs or hypertrophic anal papillae should be removed as sources of local irritation. If hemorrhoids are present, they should be treated; and cryptitis especially should be searched for and, if found, appropriate therapy should be suggested. Regulation of the bowels to prevent accumulation of materials in the lower rectum is worth while. Irritating discharges from anal fistulas or cervical discharges in females should be given appropriate treatment. In the occasional case of pruritus associated with the menstrual period, there will be discovered a very definite edema of the median raphe, which may be traumatized by the wearing of a sanitary napkin; this factor may be obviated by the use of the vaginal tampon. Excision of the edematous median raphe has been per-

ano, or from leukorrheal discharges in females

Still others believe that the secretions and the discharges from the anal canal and the lower rectum itself are the source of the moisture in the perianal region. They mention the presence of a relaxed sphincter, prolapsed internal hemorrhoids, hypertrophied papillae, infected crypts and other lesions of the anal canal which permit the escape of small amounts of mucus.

Lesions of the lower rectum, proctitis and the retention of large fecal masses, described as rectal constipation, are other causes of irritating anal discharges Whether these lesions produce pruritus by the formation and the escape of mucus from the lower bowel is problematical Certain it is that they are often etiologic factors; on the other hand, one frequently sees an intense perianal excoriation without marked pruritus in cases of ulcerative colitis and other irritative and inflammatory lesions of the lower bowel. The fact that many patients are relieved of their itching by the passage of small amounts of flatus suggests the possibility that distention of the lower rectum may in some way produce the local itching.

Another factor which is often cited as the cause of pruritus is local uncleanliness. This factor is a common one and may account for many of the minor degrees of itching. In the more marked cases, however, it is believed by some that there is a sensitization to the bacteria of the stool and of the rectal secretions. The epidermophyton causing ringworm of the feet and toes is often a primary or a secondary invader. It is thought to be transmitted by the patient from the toes to the perianal region. The characteristic picture is a thick, moist, grayish skin, with deep radiating folds of skin and shallow linear erosions in the crevices between (Fig. 283).

There is evidence pointing to the fact that venous congestion may cause a mild edema of the skin at the anal orifice which produces a secondary itching. This factor is noted in those cases of pruritus which respond to the injection of internal hemorrhoids It is more strikingly seen in cases in which itching is associated with thrombosis of a small external hemorrhoid and in cases of edema of the median raphe in females during or immediately following the menstrual period.

Finally, there is a large group of pa-





Fig. 282 (*Left*). Pruritus ani Note the excoriation of the perianal skin and the edematous skin tab

Fig 283 (*Right*). Pruritus ani, showing the thickened perianal skin with deep fissures and furrows between the perianal folds. Note the excoriation due to scratching.

a new method of therapy for pruritus ani has become available. Hydrocortisone acetate applied locally in a 1 or ½ per cent ointment apparently has some local antipruritic effect, although its exact mode of action is not yet well understood.[1] The ointment may be used with hydrocortisone acetate alone, or in combination with neomycin sulfate.* Becker[2] advises that the perianal skin should first be washed thoroughly with pHisohex. After this is rinsed off and blotted dry with cotton, hydrocortisone ointment the size of a pea is applied with the finger and for 5 minutes is massaged into the perianal skin and the anal orifice. This routine is followed in the morning after bowel movement and at night before retiring. A favorable response should be obtained within 24 to 48 hours. When complete relief of itching is obtained, the treatment may be reduced to once daily and finally discontinued after a month or so when the skin appears to have regained its normal texture. With this mode of therapy, Becker has obtained complete relief of symptoms in 110 of 160 cases. His best results were in cases of idiopathic nonspecific pruritus ani which had failed to respond to other methods of treatment. Except for a burning sensation in 2 cases, no untoward results were noted.

In addition to these more or less conservative local measures, some general instructions and systemic therapy should be given. A bland diet, avoiding stimulants, is prescribed; if any relationship has been noted between the itching and the ingestion of any specific foodstuffs or coffee, the offending substance should be eliminated from the diet.

There is some reason to believe that in some cases pruritus may have an allergic basis. The author's attention was first drawn to this when a patient with intractable pruritus reported relief of his itching when he was given an antihistaminic drug in the treatment of a nasal allergy. Since that time antihistaminic drugs have been used routinely in the treatment of pruritus ani.

Scratching is strongly interdicted, since little improvement in pruritus can be expected as long as it is continued. If the patient scratches during sleep, cotton gloves should be worn to bed. Instead of toilet paper for cleansing, cotton moistened with warm water and a mild soap or, in acute cases, with oil, should be used, and in no circumstances should there be any vigorous rubbing of the perianal skin. Finally, some provision should be made to ensure the patient's obtaining a good night's rest. The salicylates plus some of the barbiturates are of value in this respect.

If these measures fail to relieve the patient, more radical procedures must be attempted; for example, various types of injections intended temporarily to destroy or to block the nerve pathways from the skin. The injection of alcohol may prove to be an effective procedure. The author first infiltrates the perianal regions with 1 per cent procaine hydrochloride solution and then injects into the subcutaneous tissues 2 min. of 95 per cent alcohol at intervals of about 1 cm. in the perianal skin, from the anal orifice to beyond the extent of the involved skin laterally, front and back. A fine needle and vaccine syringe should be used for this injection. Before the patient leaves the office, he should be provided with several tablets of ⅙ gr. morphine sulfate, because considerable stinging and burning is present after the procaine wears off. This, however, lasts only a few

formed in several cases with good results.

In some cases of pruritus, there is an associated tightness of the anal canal which is believed to be due to the formation of a pecten band, a band of fibrosis in the mid-portion of the anal canal. This is thought to develop because of a chronic congestion in this area and is looked upon by some as a cause of the pruritus. In cases of itching in which the anal canal is tight, a division of the pecten band under local anesthesia may be easily performed, and in many cases it gives almost immediate relief of symptoms.

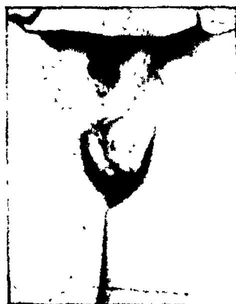
After eradication of all apparent local causes—and in many cases there are no causes to be discovered—many patients continue to have itching. This is probably due to changes in the skin of the perianal region itself, and, therefore, the itching is no longer initiated by the anal lesion. The problem, then, is one of attempting to return the skin to normal.

The first important measure is to prevent further irritation. This means no further scratching or rubbing of the perianal skin. The patient must recognize that scratching and rubbing with toilet paper increase the perianal irritation and so prolong the itching, therefore, toilet paper should be avoided. The next therapeutic indication is an attempt to return the perianal skin to normal. Application of moist heat is the most effective measure. This may be accomplished best by the use of hot sitz baths For home use, sitz baths may best be taken in a large bowl or a dishpan. (The bathtub is not used because 3 or 4 hot baths daily are quite enervating.) Plain hot water is used in the bath, as hot as can be tolerated comfortably. Sufficient water should be used to cover the perineum. During the bath, the perianal and the perineal skin is bathed with a moist cotton wad. The bath should last about 10 minutes, after which the perineum is dried by blotting with dry cotton. Instead of using toilet paper, sitz baths should follow each bowel movement, and there should be at least 4 daily, the last one just before going to bed. After the sitz bath, the perianal skin is protected with a mild antipruritic ointment. The author has found that 3 per cent ichthyol in zinc oxide ointment is effective in about 90 per cent of the cases of mild inflammation.

In more intense infiltration and lichenification, crude coal tar ointments are used as follows: Crude coal tar 8 Gm., zinc oxide powder 8 Gm., cornstarch 60 Gm. and petrolatum 60 Gm. The ointments prevent maceration of the skin and shield it from discharges from the rectum or the vagina. If this plan of therapy can be followed conscientiously, it will permit the skin to return to its normal texture. Relief of itching will result in a large percentage of cases.

In those cases in which the perianal skin shows a moist, soggy appearance with deep fissures between the rugae, the trichophyton is frequently a secondary factor and various types of fungicidal ointments may be used. Half-strength Whitfield's ointment often gives relief in such cases. The patient should be warned of some smarting or burning following its application; this is not intolerable, however. Instead of this ointment, the area may be painted with 10 or 20 per cent silver nitrate solution; this may produce a slight smarting or burning for a time. The treatment may be repeated in 2 or 3 days. In the meantime, ordinary zinc oxide ointment should be used as a protective dressing.

Since the advent of adrenal steroids,



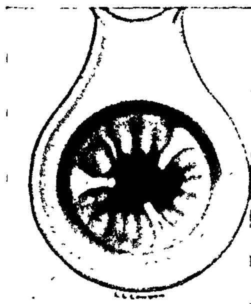


FIG. 285 (*Left*). Hypertrophied anal papilla which became polypoid and prolapsed with each bowel movement. This papilla was excised under local anesthesia, and the patient, a hospital employee, lost no time from her work.

FIG. 286 (*Right*). Hypertrophied anal papillae of the usual size, as seen through the anoscope. They project as small teatlike bodies into the anal canal at the mucocutaneous junction.

large to a polypoid tumor the size of a hickory nut (Fig. 285).

Symptoms. The symptoms produced by hypertrophied papillae are varied. Frequently, they are the cause of pain at the time of bowel movements due to a drag or pull as the stool mass passes over them. Often, bleeding is an associated symptom. Often, they cause anal discomfort by prolapsing during exercise. They may be one of the causes of anal irritability, spasm and itching. In 25 recent cases of papillitis, the presenting symptoms were: pain, 11 cases; pain and bleeding, 5 cases, bleeding, 4 cases; pain and itching, 3 cases; itching, 2 cases.

Diagnosis. The diagnosis is made by palpation and inspection of the anal canal. If the external sphincter is relaxed, the papillae often appear in the anal orifice when the patient strains and the canal is everted by the examiner's fingers. The characteristic nodules are easily recognized by palpation with the finger. They are found within the anal canal, arising from a base midway between the sphincters. With an anoscope they may be visualized (Fig. 286).

Treatment. The treatment is removal of the hypertrophied papillae when they produce symptoms. After local infiltration at the base of the lesions through an anoscope, the tips of the papillae are caught with an Allis forceps and excised with a cautery or scissors. The resulting lesions are often painful for a few days, but the discomfort may be relieved by hot sitz baths.

When hypertrophied papillae occur in association with fissures, cryptitis or hemorrhoids, they may be taken care of at the time of the treatment of the other lesion (Fig. 287).

hours and does not contraindicate the ambulatory care of the patient.

The *author has* used Efocaine instead of alcohol in a fair number of cases. The perianal skin and the subcutaneous tissues are infiltrated with 1 per cent procaine hydrochloride from the anal orifice outward beyond the area of itching. A needle is then used to make concentric ring-shaped scratches in the anesthetized skin about 1 cm. apart, beginning at the anal orifice. The scratch marks are used as guides for the deposition of Efocaine. The Efocaine solution, contained in a vaccine syringe fitted with ½-in. 21-gauge needle is deposited in the subcutaneous tissues by inserting the full length of the needle at right angles to the skin surface and injecting from 1 to 2 min. Such injections are made at intervals of 1 cm. on the scratched rings. Often only one half of the perianal area is treated at one sitting. Usually the area of worst itching is treated at the first sitting, and the rest of the perianal area is injected a week later.

Good relief of itching without any complications has been obtained by this therapy, but recurrence of itching may take place.

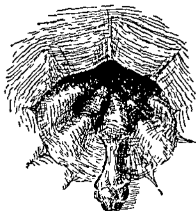


FIG. 284. Hypertrophied anal papilla.

Roentgen therapy in the treatment of pruritus ani should be mentioned. In some cases, irradiation gives relief for a period of from 3 to 6 months and sometimes longer. Unfortunately, however, permanent results cannot always be anticipated, and this should be explained to the patient if this form of treatment is to be used.

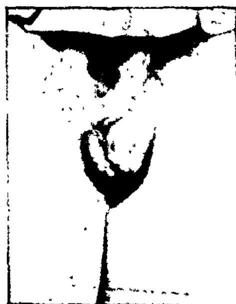
The prognosis in anal pruritus should be guarded. Relief of the itching is very often followed by recurrence, although the incidence is less when alcoholic injections have been given.

HYPERTROPHIED ANAL PAPILLAE

Papillitis

The dentate line in the anal canal is marked by small conical projections from the skin margin: these are called papillae. Normally, they are soft and tend to flatten out as the anal canal is dilated by the passage of the stool mass.

Etiology. The papillae often become hypertrophied as a result of trauma produced by the evacuation of a large hard stool or by repeated spasm of the sphincter in diarrhea. Infectious inflammation plays a significant role in the hypertrophy of the papillae which are associated with cryptitis and fissure. When hypertrophy occurs, the papillae may easily be identified by palpation as hard teatlike nodules, which are easily movable over the wall of the anal canal. They enlarge, becoming 2 or 3 times their normal size, and they may even assume the proportions of true polyps. (Fig. 284) Occasionally, a hypertrophied papilla has been observed to en-



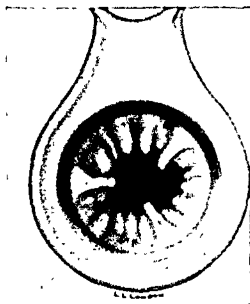


FIG. 285 (*Left*). Hypertrophied anal papilla which became polypoid and prolapsed with each bowel movement. This papilla was excised under local anesthesia, and the patient, a hospital employee, lost no time from her work.

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Symptoms. The symptoms produced by hypertrophied papillae are varied. Frequently, they are the cause of pain at the time of bowel movements due to a drag or pull as the stool mass passes over them. Often, bleeding is an associated symptom. Often, they cause anal discomfort by prolapsing during exercise. They may be one of the causes of anal irritability, spasm and itching. In 25 recent cases of papillitis, the presenting symptoms were: pain, 11 cases, pain and bleeding, 5 cases; bleeding, 4 cases; pain and itching, 3 cases; itching, 2 cases.

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Treatment. The treatment is removal of the hypertrophied papillae when they produce symptoms. After local infiltration at the base of the lesions through an anoscope, the tips of the papillae are caught with an Allis forceps and excised with a cautery or scissors. The resulting lesions are often painful for a few days, but the discomfort may be relieved by hot sitz baths.

When hypertrophied papillae occur in association with fissures, cryptitis or hemorrhoids, they may be taken care of at the time of the treatment of the other lesion (Fig. 287).

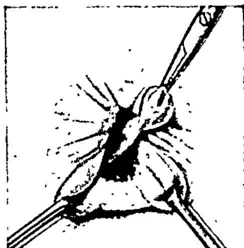


Fig. 287 Hypertrophied anal papilla occurring at the upper end of an anal fissure These 2 lesions are occasionally associated, and, for this reason, every anal fissure should undergo a careful digital examination.

PYOGENIC INFECTIONS OF THE ANAL CANAL

Almost all the pyogenic infections at the anal canal may be looked upon as having a common origin in the crypts of Morgagni. These crypts, which may be deep pockets when the anal canal is closed, lie above the anorectal line. They are lined by mucous membrane, and deep tortuous glands extend from them into the submucous tissues.[11] In addition, there are patches of lymphoid tissue which lie underneath the mucosa. An infection may extend from the crypt pockets to these glands and lymphoid tissue, giving no symptoms until it reaches the adjacent skin tissue. Then, because of the inflammatory edema, the overlying papillae become prominent and pain becomes a symptom.

When an infection in the anal crypts progresses by burrowing, it may extend between the sphincter muscles and the mucous membrane toward the anal orifice to form a perirectal abscess, or it may perforate and thus form an ischiorectal abscess. (Fig. 288)

Cryptitis

Etiology. Normally, the pockets lying between the columns of Morgagni flatten out with the passage of the stool mass. They are formed by the puckering action of the sphincter muscles and are absent in the cadaver, where the muscle tone is lost. Trauma incidental to the evacuation of large hard stools in constipation, the frequent anal spasms in diarrhea, the insertion of enema tubes or the lodging in the crypt of hard foreign materials of the stool permits infecting organisms to gain entrance into the tissues. The relatively deep pocket in the crypt may not drain spontaneously, and the inflammation extends to the lymphoid tissue and the glands underlying its surface. The crypts most often involved lie in the posterior half of the anal ring and, in the majority of cases, at the posterior commissure (Fig. 288:1).

Symptoms. When confined to the mucous membrane and the submucous tissue, the infection may produce no symptoms noticeable to the patient. When, however, the inflammation extends to the adjacent papillae, producing an edematous swelling of this sensitive tissue, anal pain and spasm become prominent symptoms. The pain is most acute at the time of and for a time after bowel movements, and for this reason cryptitis is often mistaken for anal fissure. As in fissure, constipation is a secondary and aggravating symptom due to the pain associated with bowel movements.

Diagnosis. The diagnosis of cryptitis can be made by digital examination if the gloved finger is inserted carefully into the anal canal. Usually, the

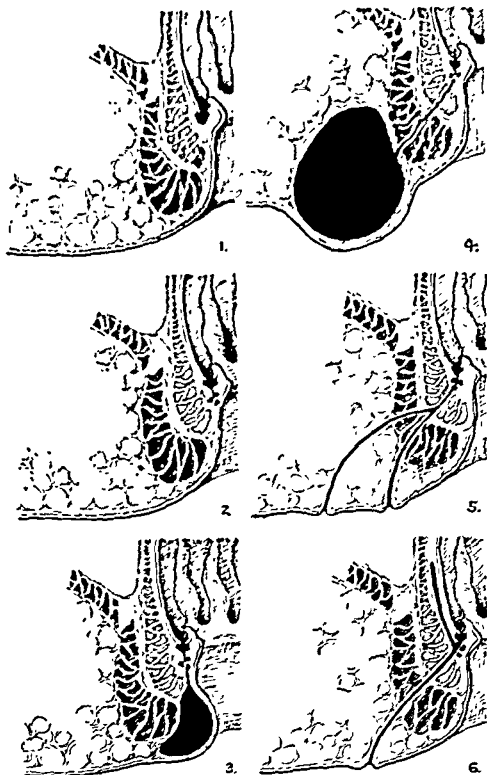


FIG 288. Semidiagrammatic drawings to show the progress of an infection from the anal crypts. (1) Infected anal crypt with ulceration (2) Extension of the infection to the deeper glands. These glands may also lie in the muscular tissue. (3) Submucous extension of the infection to form a perianal abscess (4) Deep extension of the infection to the fat of the ischiorectal fossa to form an ischiorectal abscess. (5) Primary and secondary fistulas leading from an infected crypt to the skin surface. (6) Secondary fistula extending upward between the circular muscle of the bowel and the mucosa. (Ferguson, L. Kraeer: S. Clin. North America 18:1647)



Fig. 289 Hooked probe inserted into an anal crypt

edematous hypertrophied papilla can be palpated, and pressure over the affected crypt gives marked pain When an anoscope is inserted, the crypt may be entered with a hooked probe (Fig. 289). As a rule, except for the edema of the skin edge, few inflammatory signs may be seen. However, the probe inserted into the crypt usually causes definite pain.

Treatment. Treatment of anal cryptitis should err on the conservative side. It does not seem logical to expect any very marked action from topical applications in the crypt, although multitudes of these have been recommended. The problem is one of hastening the subsidence of the inflammation or of producing adequate drainage if the inflammation continues because of its deep location. As an aid in reducing the inflammation, warm rectal instillations are beneficial in keeping the parts clean and the crypts empty. Simple physiologic saline, used in amounts of from 300 to 500 cc., is satisfactory in this regard.

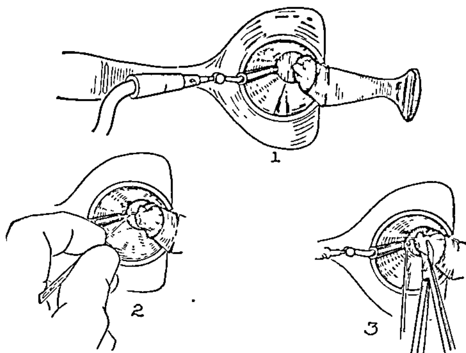


Fig 290 Appearance of an infected crypt through a Brinkerhoff anoscope (1). Using a hooked probe (2) as a tractor, the overhanging skin edge and the edematous papilla are excised with long curved scissors (3).

Sitz baths may also be used as a method of applying heat. To this therapy should be added instructions as to a bland diet, often with the addition of mineral oil. This form of conservative treatment should be given a thorough trial before operation is considered necessary.

When the infection has begun to burrow so that the exploring probe hooks into a deep opening overhung by the tissues at the dentate line (Fig. 288:2), the indication for treatment is adequate drainage. With a speculum inserted into the anal canal, the pocket of the infected crypt can easily be identified with the hooked probe. Then, with infiltration anesthesia in the tissues overlying the probe, drainage may be obtained by cutting away the hypertrophied papilla and adjacent skin edge (Fig. 290). This *operation* is best performed by using the hooked probe as a tractor, the tissues beneath the hook are excised with narrow scissors, and in this way the deep pocket is converted into an open wound. Bleeding is usually slight and can be controlled by the insertion of plain or petrolatum gauze into the anal canal for a few hours. Frequently there is postoperative discomfort lasting for 24 hours; this can be relieved by hot sitz baths and anesthetic ointments. After 48 hours, there is little discomfort except at the time of bowel movements.

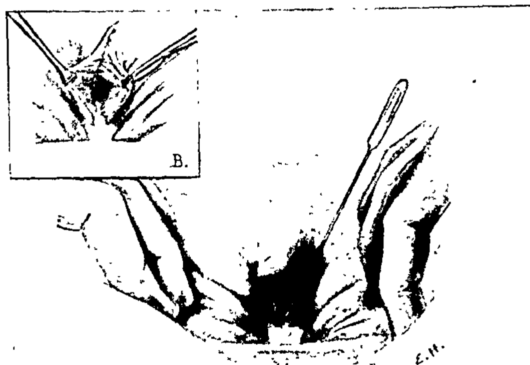


Fig. 291. Perianal abscess in the posterior midline. When the buttocks were spread apart, pus could be seen escaping from the infected crypt.

Perianal Abscess

When the infection of an anal crypt extends deeply to the perianal lymphatic tissue and then burrows caudally between the mucous membrane and the anal muscles, an abscess forms and presents at the anal orifice; this is called a perianal abscess. This type of lesion appears most often at the midline posteriorly as a painful reddened swelling. (Figs. 288:3 and 291)

Diagnosis. The history given by the patient may often be misleading as to the true course of the infection. There may be no previous history of a painful cryptitis, although there is often a period of several days during which the patient has noted slight discomfort and soreness in the anal canal. The pain then becomes marked and almost intolerable at the time of bowel movements; usually it is sufficient to keep the patient awake at night. The systemic reaction is slight. On digital examination, an indurated, rounded, tender mass may be palpated just outside the anal wall, usually in the posterior half of the anal canal and on one side or the other of the mid-line. The abscess may be situated at the level of the infected crypt or, more commonly, close to the anal orifice. Usually, a tender edematous papilla marks the location of the crypt.



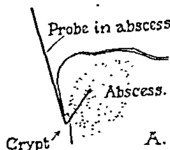


FIG 292 Incision and drainage of a perianal abscess. The infected crypt is identified with a hooked probe (A), and, after line infiltration with local anesthesia, an incision is made over the dome of the abscess into its cavity The lips of the wound are held apart by Allis forceps while the pus is removed with soft cotton or an aspirating tip (B).

By pulling the buttocks apart, pus may be seen to escape from the anal orifice. An anoscope can be introduced gently without pain if pressure is maintained away from the area of the abscess. The infected crypt can then be identified by the drainage of pus from it, and the hooked probe will extend through it into the abscess cavity (Fig. 292).

Treatment. The treatment of such an abscess is relatively simple and may be carried out without admitting the patient to a hospital. The results are almost immediate relief of pain and discomfort. With the speculum in place and the hooked probe in the infected crypt, infiltration anesthesia is introduced with 1 per cent procaine solution. Usually, it is best to infiltrate at the crypt opening first, because the edema of a local anesthesia may obscure this area if the anesthetic is first introduced over the swelling of the abscess cavity. No effort is made to obtain a deep anesthesia. The skin overlying the abscess is anesthetized from the infected crypt to the farthest extent of the abscess cavity at the anal orifice. It is well to carry

the infiltration somewhat laterally in order to permit Allis forceps to be applied and to allow the excision of the central portion of skin over the abscess cavity.

A single incision is then made to drain the cavity, and, after removal of the purulent material by suction or gentle sponging, the edges of the wound, including the edematous hypertrophied papilla, are excised. The cavity is then gently packed with petrolatum or narrow iodoform gauze. Care is taken to see that the packing does not lie in the lumen of the anal canal.

The operation as described above is not absolutely painless, but it may be performed with a minimum of discomfort. The sponging of the unanesthetized abscess cavity and the insertion of packing are the procedures which cause pain. If the patient is warned beforehand and if gentleness is used, little difficulty is experienced.

The wound is dressed with gauze held in place with a T-binder. As a rule, incision of the abscess causes almost immediate relief of pain, but it is well to provide the patient with 2 or 3 tablets of morphine, to be taken by mouth every 3 hours if needed for the relief of pain during the first night after operation. A liquid diet may be prescribed for 1 or 2 days. On the third postoperative day, the packing is removed and none is reinserted. Sitz baths of warm physiologic saline once or twice daily and after each bowel movement are used as an easy and efficient method of keeping the wound macroscopically clean during the healing process. The ordinary sanitary napkin makes a convenient and an easily obtainable dressing after the wound begins to granulate, on about the fifth or the sixth day. No secret is made of the fact that this wound is not and never can be considered sterile, but ordinary cleanliness is enforced. Occasionally, drainage from the wound will cause excoriation and chafing of the cheeks of the buttocks. The application of a thin layer of zinc oxide ointment at the site of irritation will give relief from this trouble in 24 hours. Usually, little or no discomfort is experienced after 24 hours, and no restriction in the diet is necessary. The passage of a formed stool is more to be desired than numerous soft or liquid stools. No cathartics are given unless indicated for reasons other than the operative wound.

Ischiorectal Abscess

When an infection from an infected crypt burrows laterally, it may pass between the sphincters or through the fibers of the external sphincter to enter the ischiorectal fossa. This pyramidal space lying between the anal canal and the tuber ischium is filled chiefly with fatty tissue and, therefore, offers little resistance to the progress of an infection. The abscess may extend rapidly in this tissue upward along the wall of the rectum or laterally round the anal canal into the fossa of the opposite side.

Symptoms. The rapid necrosis of the fatty tissue does not permit a walling off of the infected process, so that a temperature elevation and other marked systemic changes often result. On local examination, a tense redness to the lateral side of the anal orifice may be seen. On palpation, either in the anal canal or over the reddened area, acute tenderness is elicited. The area is usually so tender that a demonstration of fluctuation is impossible in the early stages of the

process, and it is unnecessary in the later stages when pus certainly is present. It is often difficult, even impossible, to demonstrate the infected crypt without anesthesia. In ischiorectal abscess, as in perianal abscess, there often is no previous history which would indicate the presence of a cryptitis. Nevertheless, the almost invariable development of a secondary fistula after the drainage of an ischiorectal abscess points to the origin of the infection in an infected crypt (Fig. 288:1 and 5).

Treatment. Because of the rapid progress of an infection in the fat of the ischiorectal fossa, incision and drainage at the earliest moment are the indicated treatment. As a rule, a general, low spinal or caudal and transsacral block anesthesia is required and hospitalization is advised, although in a few cases simple incision of the abscess may be performed under local infiltration anesthesia in ambulatory patients, with the knowledge that a secondary fistula will probably result. With the patient in the lithotomy position or in the Sims's position with the involved side down, an infiltration with 0.5 per cent procaine is made carefully over the dome of the abscess. In making the infiltration, it must be remembered that pressure upon an abscess wall by increasing the tension in the abscess causes definite increase in pain. It is imperative, therefore, to make every effort to avoid pressure. The line of infiltration should be radial and long enough to permit an incision which will open the entire extent of the abscess. Local anesthesia does not permit a completely painless operation, but the relief of tension immediately following the incision gives such relief to the patient that it may be performed without difficulty under this type of anesthesia. General anesthesia may be used, but the difficulty of keeping the patient in position on the table, unless it is relatively deep, has made local anesthesia the choice for the incision of ischiorectal abscesses in ambulatory patients.

The incision is made after gently inserting the index finger of one hand into the anal canal. Avoiding downward pressure upon the scalpel as much as possible and cutting through the skin and the subcutaneous tissues with sweeping strokes of the knife, the abscess cavity is entered. Frequently, the foul-smelling pus spurts out with considerable pressure, and it is well to hold a protecting sponge to avoid wide scattering of the pus from large abscesses. In the smaller early abscesses, the knife is guided toward the abscess cavity by the finger in the anal canal. In these deeper smaller abscesses, it may be necessary to make deeper infiltration of the subcutaneous fat to obtain anesthesia.

After the abscess cavity is entered, Allis forceps are placed upon the lips of the wound and an exploring finger is inserted gently, bearing in mind that the anesthesia is confined to the wound through which the incision has passed. With the finger in the abscess cavity, it is possible to outline its extent, and the incision should be continued until the entire cavity is laid open.

The wound is then held open with Allis forceps or rake retractors while it is cleaned gently with an absorbent gauze sponge. The cavity is then packed with plain or iodoform gauze, a special effort being made not to break any of the vessels that extend like fibrous cords from the lateral wall of the ischiorectal fossa to the

anal canal and the rectum. Dressings are applied and held in place by a T binder. The postoperative care is similar to that mentioned for perianal abscess. After removal of the packing on the third day, the wound edges are held apart by the insertion of a simple gauze dressing. Warm saline sitz baths after each movement and 2 or 3 times daily in addition keep the area clean and permit the mechanical removal of the remaining necrotic tissue. With *this type of operation,* healing usually takes place in from 2 to 3 weeks.

Most cases of ischiorectal abscess should be admitted to the hospital for operation. This is especially true if there is an associated high fever, if the abscess is large, or if urinary symptoms, indicating involvement of the prostate gland and the urethra in the inflammatory process, are present. There are, however, frequent instances in which hospital admission may be impossible or refused. If the abscess is small, relief of pain may be obtained by incision with the knowledge that a secondary fistula may later appear.

Antibiotics and Anal Infections

In a general way it may be said that antibiotics are not of great value in the treatment of perianal and ischiorectal infections. These lesions are rarely seen until they are in the abscess stage, and in that stage antibiotics are no substitute for incision and drainage. If adequate drainage is provided, the need for antibiotics is slight and their value is negligible. Furthermore, the infecting organisms are rarely those which are sensitive to antibiotics. Rosser[13] believes that they "slow the process, and change the clinical picture, at times sufficiently to confuse the diagnosis or give a false sense of security," even when given early.

Fistula in Ano

Etiology. Fistula in ano is the third type of lesion which may arise from an infected anal crypt. This is a tubular tract lined with infected granulation tissue which extends from the infected crypt outward to the skin surface at one side or the other of the anal orifice. *This infected tract may* appear as a sequela of an ischiorectal abscess. The abscess being drained by an incision, there still remains the infected crypt and the infected tract leading from it through the ischiorectal fossa. As a result of the incision, the abscess cavity heals by granulation up to and round the drainage tract which extends to the skin surface at the site of the incision Sometimes the abscess may heal entirely by granulation and the wound will break open some time later with the appearance of a fistulous opening More commonly, however, the fistula appears without any preexisting acute ischiorectal abscess. In such cases, the organism may be of a lower virulence or the tissues of higher resistance In any event, the infection extends from the anal crypt across the inner part of the ischiorectal fossa to form a small subcutaneous abscess. This usually ruptures spontaneously and a fistula remains.

Not infrequently, the fistulous tract is tortuous, and secondary fistulous openings may appear on the skin surface These tracts arise from closure of the primary tract, with burrowing of the infection through the wall of the original fistulous canal to the surface, and in many cases the tract leads upward along the anal canal and the rectum. Almost invariably, however,

these numerous tracts arise from a single infected crypt (Fig. 288:5 and 6).

Symptoms and Diagnosis. The symptomatology of fistula in ano is diagnostic. The patient states that he notices a drainage of thick malodorous material from the fistulous opening. The drainage is sufficient to soil the clothing and requires a pad of cotton between the buttocks. For a time, as the scar tissue at the skin opening contracts, the drainage may become less; eventually the external opening may close entirely and the patient may consider his fistula healed. Gradually, however, the infected material of the tract produces a small subcutaneous abscess at the site of the cutaneous opening, and the patient develops pain and soreness. In 2 or 3 days, the abscess ruptures at the scar of the cutaneous opening of the fistula. The pain is relieved but the drainage becomes apparent again, at first profuse and then, as the acute inflammatory process subsides, less and less until it reaches the original amount. This continuous infection produces a fistulous tract lined by infected granulation tissue and its wall made up of dense fibrous tissue. In a long-standing fistula, the cutaneous opening is easily recognized by its raised circle of scar tissue from which a drop or two of pus may easily be expressed. By palpation, the fistulous tract may often be identified as a firm fibrous cord extending toward the anal canal. The secondary tracts usually arise due to the damming up of the infection by a healing over of the cutaneous opening Most frequently, the secondary opening is found to connect with the original fistula by a subcutaneous tract and may be at considerable distance from the original opening. There may be a large subcutaneous pocket lined by chronic granulation tissue.

A rule frequently quoted for locating the internal opening has been found to be very useful from practical experience: an imaginary line is drawn between the tubera ischii so as to bisect the anal orifice transversely. If the primary external opening of the fistula lies anterior to this line, the internal opening is usually in an infected crypt on a straight line drawn from the external opening to the anal orifice; if the external opening of the fistula lies posterior to this line, the fistulous tract usually has its origin in an infected crypt at, or just lateral to, the mid-line posteriorly and is usually a curved one (Fig. 293A). When there are secondary openings, some of which lie anterior to this line, the sinus tract is usually found to be of the posterior type.

Treatment. The treatment of fistula in ano is incision or excision of the fistulous tract from the infected crypt to all the cutaneous openings. When the skin opening of the fistula lies close to the anal orifice and when the tract can be identified easily by palpation or by the gentle insertion of the probe along its course, it is possible to excise the fistula under local anesthesia, and the patient may be ambulatory throughout his period of treatment. With the finger in the anal canal, a probe is introduced through the fistulous tract to emerge at the infected crypt. The end of the probe is then advanced slowly so that it appears at the anal orifice. Although this may cause the patient slight discomfort, it is much better to insert the probe before the injection of a local anesthetic has caused distortion of the tract (Fig. 293B). One per cent pro-

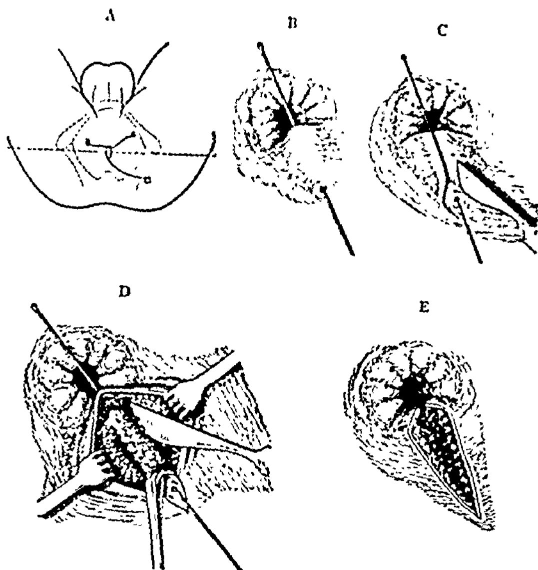


FIG. 293. (A) Position of the skin opening in relation to the anal opening of a fistula in ano. An imaginary line is drawn to bisect the anal orifice between the tuber ischii. A fistula in which the cutaneous opening lies anterior to this line extends to the anal canal in a radial direction. If the cutaneous opening of the fistula lies posterior to this line, the anal opening is almost invariably at a crypt in the posterior mid-line.

(B) Short fistula in ano identified with a probe inserted from the cutaneous opening to the infected crypt. Procaine, 1 per cent, containing epinephrine is infiltrated along the line of the fistula and round the cutaneous opening.

(C) Skin incision for excision of a short fistula in ano.

(D) Excision of fibrous fistulous tract as a cylinder upon the identifying probe.

(E) Wedge-shaped wound resulting from excision of the fistulous tract is packed with plain or iodoform gauze Healing by granulation is permitted.

caine containing epinephrine is then injected into the tissues above and round the probe, an adequate skin infiltration first is made, then the tract is surrounded by a wall of local anesthesia. As a rule, it is best to begin the infiltration at the anal end of the fistula, otherwise, later injections may obscure the internal orifice and an incomplete infiltration will result. The tissues are then incised down to the fistulous tract (Fig. 293C). Using sharp rake retractors or Allis forceps, the lips of the wound are pulled apart and the incision is carried down to expose the tract (Fig 293D)

In a fistula of any duration, the tract has become so fibrous as to permit its excision intact. If the incision is carried to the probe and the fistulous tract is laid open, it is wise to excise the cartilaginouslike scar tissue of the fistula. The edges of the wound are excised so as to make a broad V (Fig 293E) and the wound is packed with iodoform gauze, care being taken to see that the packing does not extend into the anal canal. A T-binder pressure dressing is applied and the postoperative care is similar to that described for perianal abscess

When the fistulous tract opens at some distance from the anal orifice or when there are multiple openings, the patient is usually hospitalized and operated upon under low spinal, caudal and transsacral or general anesthesia, although the author has operated upon numerous such cases under local anesthesia in ambulatory patients. With the patient in the lithotomy position, the anal canal is dilated and held apart by 4 Allis forceps. With a hooked probe, the infected crypt which marks the internal opening of the fistulous tract is then searched for, and, when it is identified, the probe is held in the crypt. In long and tortuous fistulas, it is not always possible to insert a probe throughout the entire length of the tract; therefore, it is imperative that the infected crypt which marks the anal opening of the tract be identified early in the operation. The most important part of the operation is the incision of the crypt, and the frequent recurrences which are seen are mostly due to the fact that the infected crypt is not laid open at the first operation.

In cases of long and multiple fistulas, it is frequently wise to perform a 2-stage operation, excising or incising first the portion of the tract farthest from the anal canal and leaving for the secondary operation the incision of the inner portion of the tract through the sphincter muscle and the infected crypt. When this type of operation has been decided upon, a probe or a grooved director is inserted into one of the fistulous openings as far as it will pass without force (Fig. 294A). An incision is then made in the direction of the probe, the skin and the subcutaneous tissues being divided down to the tract (Fig 294B). The skin incision is carried round the fistulous opening, and, with Allis forceps and sharp rake retractors holding the skin on tension, the tract may be dissected out intact down toward the anal canal. When secondary tracts are found leading into the primary fistula, these are dissected out in the same manner. As the dissection progresses, the fistulous tract is held taut on the grooved director or the probe with a hemostat. Usually, the director will pass without any effort along the tract as it is dissected free and its curves are obliterated, so that eventually it will emerge in the anal canal at the crypt previously identified by the hooked probe (Fig. 294C). When the dissection has been carried down

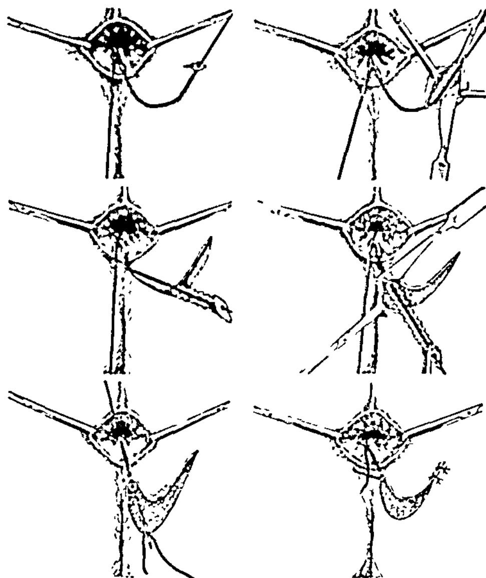


FIG 294. (A, *Top, left*) Technic of the 2 stage excision of fistula in ano; identification of the infected crypt in the posterior commissure and passage of the probe into the external opening as far as the tract will permit

(B, *Top, right*) Beginning excision of the tract from the external opening, the edges of the wound being kept on tension with retractors or Allis forceps

(C, *Center, left*) The lateral portion of the tract having been dissected free, the probe may be advanced along its course and the incision continued toward the anal opening

(D, *Center, right*) The tract is dissected free up to the anal musculature, being kept taut on the probe with a hemostat. When the dissection has reached the anal musculature, the tubelike fistulous tract is divided and the probe is passed onward through the infected anal crypt.

(E, *Bottom, left*) The probe, having been passed through the infected crypt, is threaded with a heavy silk suture, which is drawn through the remaining portion of the fistulous tract and remains as a seton until the second-stage operation.

(F, *Bottom, right*) The lateral portion of the tract is partially closed with buried sutures of fine catgut, and silk in the skin. The mesial portion of the tract is packed with iodoform gauze and allowed to heal by granulation up to the seton. When healing has progressed to the seton, the mesial portion of the tract is excised at a second operation.

(Ferguson, L. Kraeer: S. Clin. North America 18:1645)

to the anal musculature, the freed portion of the fistula is cut off and drawn off the probe (Fig. 291D), and the probe, threaded with a doubled silk ligature, is pulled through the remaining portion of the tract (Fig. 291E). The silk thread, which now identifies the mesial position of the fistulous tract, is tied loosely with a triple knot to remain in place as a seton until the time of the second-stage operation (Fig. 291F).

When a secondary sinus tract passes upward along the anal canal and the rectum, no effort is made to excise it. As a rule, it is best to lay it open as far as possible without destroying the integrity of the musculature, and the chronic granulation tissue is removed with gauze or a curet. This tract will heal spontaneously if the primary opening at the infected crypt is drained.

In cases in which the tract has been excised as described, in spite of the fact that the wound is definitely infected, almost primary union may be obtained by suturing if care is taken to obliterate dead space. Often the wound is irrigated with saline before suturing is attempted. The sutures should be of fine catgut and so placed, layer upon layer, as to obliterate the wound left by the excision of the fistula. The inner portion of the wound is not completely sutured but is packed lightly with iodoform gauze next to the seton. If the subcutaneous sutures are placed sufficiently close to the surface, it is best not to attempt to suture the skin because these wounds often become edematous for a few days, especially when skin sutures have been inserted.

In the postoperative care of these patients, warm moist compresses are applied for 15 minutes every second hour, beginning 24 hours after operation. The packing is removed on the third postoperative day and is not replaced. The moist compresses are continued until the fourth or the fifth day, after which hot sitz baths of physiologic saline solution are substituted. Frequently, there is a considerable reaction in these wounds; this will subside without suppuration by the use of hot moist dressings. When the wounds have healed solidly up to the seton, usually in 10 days to 2 weeks, the second stage of the operation may be performed. This may be carried out under local anesthesia and in the ambulatory patient. The tissues included in the seton are well infiltrated with procaine solution, and an incision is made down to the fistulous tract identified by the seton. As a rule, the edges of the wound are excised and iodoform gauze is inserted. The postoperative care is then as described for perianal abscess (p. 405). With this stage treatment of extensive fistulas, the resulting scar and deformity are minimal, and, as a rule, there is little or no interference with sphincter function.

Fissure in Ano

Etiology. A painful longitudinal ulcer of the anal canal is called a fissure in ano. Most often, this ulceration appears as an infection of a traumatic wound produced by a splitting or a tearing of the skin tissues at the anal orifice by the passage of a large hard stool. Because of the direction of the anal canal in relation to the lower rectum, the stretching and the tearing of the thin skin at the anal margin most often occur at the posterior commissure. There may be a slight amount of oozing incidental to the injury, but

in the majority of cases healing takes place without complication. In those cases in which the tear becomes an ulcer, infection occurs with resulting inflammation of the wound and of the surrounding tissues. The inflammatory reaction frequently produces edema of the papilla at the upper margin of the ulcer and extends by contiguity to the sphincter muscles. The acute fissure is thus produced.

Symptoms. The symptoms produced by acute fissure (Fig. 295) are pain and bleeding. The pain occurs characteristically with the stool, and usually it persists for a period of from half an hour to 2 or 3 hours after defecation. Usually, the bleeding is small in amount and may be noticed only as a soiling of the toilet paper or a staining of the clothes. The method by which these symptoms are produced is easily understood if the underlying pathology of the fissure is kept in mind. The trauma to the irritable ulcer due to the passage of the hard stool over it and to stretching of the tissues causes intense pain which is followed by a spasm of the sphincter muscle. This spasm further traumatizes the ulcer and prolongs the pain for a considerable period after bowel movements. Defecation is such a painful procedure for these patients that it is often avoided as long as possible, with the result that the stool mass becomes larger in size and harder as the water is more completely absorbed from it. The following movement is more painful than ever. The dread of a bowel movement results in constipation, and the severe pain during and persisting after defecation may so upset an otherwise normal person as to make him a nervous wreck.

As the process continues, scar tissue forms at the edges of the ulcer and especially at the skin surface of



Fig. 295 (*Left*). Acute fissure at the usual site at the posterior mid-line of the anal orifice.

Fig. 296 (*Right*). Chronic fissure. Note the hypertrophic skin tissue commonly designated as a sentinel pile.

the anal orifice, where there are edema and secondary fibrosis with the formation of a definite overhanging mass of skin and fibrous tissue called a sentinel pile (Fig. 296). This is easily noted on inspection and almost invariably lies at the posterior mid-line, the location of about 90 per cent of anal fissures. With the passage of time and the deposit of fibrous tissue in and round the fissure, the symptomatology changes to that of the chronic fissure in ano. The acute pain with persisting spasm is no longer present, and bleeding is rare. The chief symptom is a duller, dragging pain at the time of bowel movement which does not persist for a long period thereafter. The pain in this case is due to the stretching of the ulcer and the underlying fibrosis and also to the dragging of the overhanging sentinel pile, which hangs as a sort of inverted hood at the external extremity of the fissure. In addition, there may be marked pain due to pulling upon a hypertrophied papilla at the upper limit of the ulcer.

Diagnosis. The diagnosis of anal fissure may frequently be made upon the history alone; the pain associated with and persisting after defecation and the appearance of small amounts of bright blood are quite typical. However, one should not rely upon the history; an examination of the anal area must be made. In this examination, the fissure can usually be visualized if the buttocks are separated. This may cause considerable discomfort. If the ulcer is extremely sensitive, the pain may be relieved by the application of a swab dipped in 10 per cent cocaine solution and inserted gently into the anal canal. The injection of procaine into the sphincter muscles and underneath the fissure is another method of permitting digital and instrumental examination without discomfort. When no anesthesia is used, the index finger should be inserted along the anterior anal wall, palm anterior, pressure being made away from the fissure. The finger may then be turned over and the area of the fissure palpated. The ulcer is noted as a depression, and one may feel the dense fibrosis which extends on either side of the fissure, often producing an almost shelflike constriction of the posterior part of the anal canal. This band of fibrous tissue has been named the pecten band. Frequently, an edematous and a fibrosed papilla at the upper margin of the fissure can be palpated as a small tender mass. The fissure may be visualized by use of an anoscope, and, in this examination, one may frequently note a small fistula that leads from the base of the fissure to the skin surface behind the sentinel pile.

Treatment. The treatment of acute fissure may be either conservative or operative. When the fissure is only a recent tear of the transitional epithelium at the anal orifice, mineral oil to keep the stool soft and hot applications or sitz baths may suffice to produce healing. Anesthetic ointments fail to add much to this regimen. When the fissure is really an anal ulcer with a flat grayish-pink base, sharply demarcated by edema of the surrounding rim of transitional epithelium, conservative treatment should be abandoned. After infiltration under and round the ulcer with procaine 1 per cent solution containing epinephrine, the base of the ulcer should be incised. The incision should be deep enough to divide a few fibers of the external sphincter and should be continued for about ½ in. in a radial direction from the anal orifice. Often

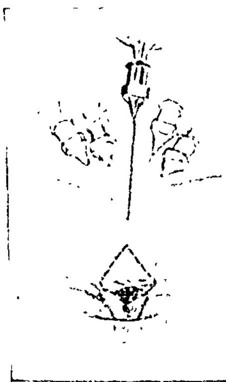




FIG. 297 Treatment of anal fissure by a perianal injection of procaine 1 per cent solution and excision of the hypertrophic sentinel pile. The dotted lines indicate the area of skin to be excised A simple gauze compress dressing is all that is necessary. (Ferguson, L. Kraeer: Pennsylvania M J. 40:911)

the edematous skin edge is cut away with curved scissors. A small gauze compress tucked into the wound is used as a dressing. The postoperative care is described below for chronic fissure.

In the chronic fissure, with a well-marked sentinel pile and with a polypoid hypertrophied papilla at its upper margin, a more extensive procedure is necessary in order to effect a cure. In such cases, it is necessary to inject procaine 1 per cent solution containing epinephrine in a wedge-shaped area round the sentinel pile and underneath the fissure. A wedge-shaped excision (Fig. 297) of skin extending from ½ to ¾ in. from the anal orifice is carried toward the anal canal, the sentinel pile and the fissure being removed. The dense fibrosis underlying the fissure (pecten band) should be divided with a light stroke of the knife and, with it, a few of the superficial fibers of the external sphincter muscle. When there is a hypertrophic papilla at the upper margin, this should be removed after ligation with a simple suture of fine catgut. The wound is packed with gauze impregnated with an anesthetic ointment, and a T-binder dressing is applied. The dressing is permitted to remain in place for about 24 hours, when it can be removed by the patient. As a rule, the patient is asked to take a sitz bath with the compress and the dressing in the wound; after the sitz bath the gauze is moistened sufficiently to permit its removal without much discomfort. Simple superficial dressings are all that are required, the area being kept clean by the use of sitz baths 2 or 3 times a day.

Practically all fissures can be taken care of in ambulatory patients. Only 7 of 125 patients with fissure in ano were admitted to the hospital. Either

these requested hospital admission or there was some reason other than the fissure for it.

POLYPS OF THE ANAL CANAL

Etiology. A polyp of the anal canal usually develops from a hypertrophied papilla. The papilla, as a result of repeated trauma in the anal canal, becomes enlarged and edematous, and eventually a fibrous nodule covered by squamous epithelium forms. Not infrequently, the inflammatory reaction extending from an anal ulcer may be the etiologic factor in the primary enlargement of the papilla. This accounts for the frequent finding of anal polyps at the cephalic end of chronic anal fissures.

These pedunculated hypertrophic anal papillae are covered with squamous or transitional epithelium, are pale pink in color, and never become malignant. They are not to be confused with adenomatous rectal polyps, which are also often pedunculated. They are, however, a velvety red in color, bleed easily, and are definite precancerous lesions.

Symptoms. The symptoms produced by anal polyps are easily understood. The usual complaint is anal pain and discomfort, especially at the time of bowel movements. As the polyps enlarge and the pedicle becomes longer, they frequently prolapse through the anal ring (Figs. 285 and 286), and many of them may remain outside the anal canal most of the time. Occasionally, ulceration of the polyp may take place and cause bleeding.

Treatment. The treatment is excision of the polyp. This operation may be performed under local infiltration and block anesthesia. A generous area at its base should be removed with the polyp. Hemostasis may be obtained by interrupted sutures of fine catgut. The postoperative care is the same as for other anal operations.

POLYPS OF THE PELVIC RECTUM

Polyps of the pelvic rectum are not uncommon. The most frequent are nodules half the size of a pea; they may be seen to arise from the mucous surface of the bowel. These give no symptoms, but their prophylactic removal is recommended because they may become larger and may take on a carcinomatous change.

Treatment. Their removal is a simple matter by basket-type biopsy forceps or by a coagulating electrode. The tissue thus obtained should be sent for histologic examination. Hemostasis may be obtained by pressure with a swab soaked in epinephrine or by eletrocoagulation.

PEDUNCULATED POLYPS OF THE RECTUM

Pedunculated rectal polyps may vary from masses the size of marbles to those so large as to encroach materially upon the lumen of the rectum They may have broad or narrow peduncles attached to the rectal wall at a relatively broad base. They are often palpable by digital examination.

Symptoms. Pedunculated polyps practically always give symptoms Their presence in the rectum subjects them to the trauma of peristalsis and of the passage of the fecal mass over them. Patients complain of a dragging sensation in the rectum at the time of bowel movements, and, in larger polyps, there is the constant sensation of incomplete evacuation. Occasionally, polyps in the lower rectum may prolapse through the anus. The presenting symptom is frequently bleed-

ing with the bowel movement. The cause of the bleeding is easily discovered by proctoscopic examination. The repeated trauma to the polyp causes an ulceration of its surface, from which bleeding occurs with each movement as the stool mass moves over the surface. The bleeding may be sufficient to cause clots to form in the rectum.

Treatment. To relieve the bleeding and the dragging sensation in the rectum, and to prevent the malignant degeneration which these polyps often undergo, removal of the polyp is advisable. The polyp may be visualized through the proctoscope, and, with a snare attached to an electrocoagulating current, it may be removed at its base without bleeding (Fig. 298), or the polyp may be removed by electrocoagulation at 1 or 2 sittings. No anesthesia is required.

Usually no specific after-care is required. A low residue diet is prescribed for about 10 days or 2 weeks to reduce the trauma which may occur from a large hard stool mass. Mineral oil is given for the same reason. The ulceration resulting from removal of the polyp heals in about 2 weeks, leaving a small scar. This area should be observed at frequent follow-up visits for a period of a year because of the danger of carcinoma in these lesions.

HEMORRHOIDS

Definition. Hemorrhoids is the name given to protruding masses of tissue in the anal canal and at the anal orifice. They are spoken of as external

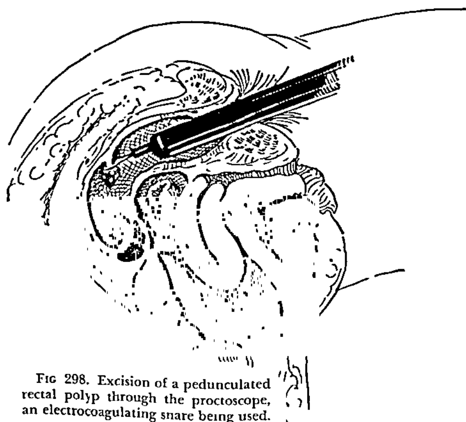


FIG 298. Excision of a pedunculated rectal polyp through the proctoscope, an electrocoagulating snare being used.

when they lie distal to the pectinate line and are covered with the modified skin tissue of ectodermal origin. They are called internal when they lie above the pectinate line and are covered by mucous membrane of endodermal origin. The combination of these 2 types, when the hemorrhoidal mass extends throughout the length of the anal canal, is spoken of as a mixed hemorrhoid.

Anatomy and Pathology. Under normal conditions there are two venous plexuses at the anal orifice and in the anal canal. These lie in the subcutaneous and the submucous tissues, and are loosely supported by the overlying tissues. The upper plexus lies above the pectinate line and drains into the middle and the superior hemorrhoidal veins. The lower plexus lies distal to the pectinate line and drains into the inferior hemorrhoidal vein. The two plexuses are united by numerous anastomotic branches, so that it is not unusual to find that both are involved in the same pathologic process. A distention of these venous plexuses may be caused by an increase of intra-abdominal pressure or a local obstruction of the venous return.

Most commonly, the cause of hemorrhoids is straining at stool, due to either constipation or diarrhea; less commonly, other types of straining in association with physical exertion may be etiologic factors. The venous stasis produced by pregnancy, and especially by childbirth, is not infrequently the cause of hemorrhoids in women. Many female patients will date the onset of their hemorrhoidal symptoms from the birth of their first or second child. Another type of venous stasis often seen is the partial obstruction to the venous return by the infiltration of carcinoma in the pelvic rectum; because of this frequent association, hemorrhoidal bleeding should be treated only after a thorough visual examination of the lower bowel with the proctoscope. Another factor somewhat difficult to explain, but nonetheless easily recognized clinically, is a relaxation of the external sphincter. With a lack of sphincter tone there is a thinning out of the anal canal in the act of defecation. This is associated with an eversion of the mucosa of the upper part of the anal canal.

External Hemorrhoids

Etiology. A dilatation of the external hemorrhoidal plexus is accompanied by a stretching and a hypertrophy of the skin tissue at the anal orifice. When venous stasis is produced by straining, the plexus becomes distended and the overlying skin is stretched into round purplish masses at the anal orifice. These are best demonstrated by examination of the patient in the squatting position or lying on the side. They are most frequently noted by the patient as masses at the anal orifice following bowel movements. The distention of the plexus usually disappears soon after the straining which produced it has stopped, so that on observing the relaxed patient there is noted only a hypertrophy of the skin at the anal orifice which is recognized by deep folds and plications.

Symptoms. The only symptoms produced by external hemorrhoids are the feeling of enlarged masses at the anus after straining and occasionally itching due to the skin hypertrophy. These symptoms of themselves rarely demand treatment. Very frequently, however, the veins of the external hemorrhoidal plexus become thrombosed, the cause of which is probably

local trauma with or without an associated infection. The appearance of thrombosis in the external hemorrhoid adds the additional symptom of pain.

The severity of the pain in the thrombosed external hemorrhoid varies according to the severity of the inflammation accompanying the thrombosis. In a large majority of cases, only 1 or 2 small venous radicals become thrombosed. These appear as firm, rounded purplish masses at the anal orifice (Fig. 299). They are tender on pressure and therefore give pain when traumatized by bowel movements or by sitting on hard surfaces. If untreated, the smaller thromboses may undergo organization and the hemorrhoidal mass will remain as a tab of skin overlying an area of fibrosis. Larger thrombosed masses may slowly progress to an ulceration of the skin overlying the thrombosed vein. A new symptom then develops, namely, bleeding in small amounts not necessarily associated with bowel movements. The blood is dark and necessitates a protective dressing. Eventually, the clot will be discharged through the ulcer and healing will take place by granulation. In other cases of thrombosis of the external hemorrhoidal veins, the inflammatory symptoms are much more marked. The overlying tissues become markedly edematous, and pain is a much more troublesome symptom. In such cases, it is often impossible to palpate a single large area of thrombosis; instead, multiple small thrombosed points are apparent, scattered throughout the area of diffuse edema.

Treatment of External Hemorrhoids. Uncomplicated external hemorrhoids rarely demand treatment unless itching becomes a prominent symptom, in which case the hemorrhoidal mass with the overlying skin may easily be excised under local anesthesia with epinephrine. The excision should be performed by the use of elliptical incisions placed radially from the anal orifice. No sutures are necessary; bleeding may easily be controlled by simple pressure with a T-binder dressing.

Treatment of Thrombosed External Hemorrhoids. When thrombosis *occurs in the external hemorrhoidal* plexus, the patient usually seeks the help of a physician because of the pain experienced. Almost immediate relief can be given in those cases in which the thrombosis is confined to one or more well-defined masses without marked edema. In such cases, the



Fig. 299. Thrombosed external hemorrhoid seen as a mass at the anal orifice.





Fig. 300. Excision of a thrombosed external hemorrhoid. The area under and round the thrombosed mass is infiltrated with 1 per cent procaine hydrochloride containing epinephrine. An elliptical incision is made over the thrombosed mass and the point of the ellipse is picked up in a hemostat or Allis forceps. The incision is then carried downward to remove the thrombosed vein with the overlying skin. A gauze compress is inserted into the anal canal to lie in the wound. No further dressing is necessary. (Ferguson, L. Kraeer: Pennsylvania M. J. 40:909)

pain seems to be due to tension in the area of thrombosis, and relief is obtained by incision and evacuation of the clot or by excision of the thrombosed segment of the vein. With the patient lying on his side, with the thrombosed area down, or in position on the proctoscope table, the area about the thrombosed vein and the overlying skin are infiltrated with 1 per cent procaine containing epinephrine (Fig. 300). With tension on the skin away from the anal orifice, an elliptical incision is made round the thrombosed vein. The flap of skin is then picked up with forceps to expose the underlying thrombosed vein, which can often be excised with the skin, as shown in Figure 300. With Allis forceps placed on each lip of the incision, any other thrombosed veins in the area are sought for and incised or are excised intact. A small square of Gelfoam is placed in the wound. The corner of a small square gauze compress 3 x 3 in. is then inserted with the forceps into the anal orifice and placed to lie in the wound. This takes care of hemostasis and no further dressing is required. The gauze is left in place for a few hours The patient is told to expect a slight amount of pain when the effect of the anesthetic disappears; this may easily be relieved by morphine sulfate gr. 1/6 by mouth. Instructions are given to keep the area clean with soap and warm water after bowel movements. The patient is warned that for a day or two there may be a slight amount of bleeding which will necessitate the wearing of a pad or the continued use of small gauze squares held in the anus. After 3 or 4 days no dressing is necessary.

This method of unroofing a thrombosed hemorrhoid by the use of an elliptical incision gives better results than the simple single incision and evacuation of the clot. The lips of such a wound often fall together, and infection in the small hematoma

which frequently develops is associated with the prolongation of pain or discomfort. In addition, healing usually results in the formation of a large skin tab which may be the source of considerable discomfort and itching.

The treatment of the thrombosed external hemorrhoid associated with marked edema is a much less simple matter. Occasionally, conservative treatment with the application of hot moist dressings will produce a gradual decrease in the inflammatory symptoms so that the above procedure of unroofing the hemorrhoid may be practiced. More often, however, the thrombosis is diffuse and not confined to a few larger segments of veins. In such cases, it is necessary to excise the inflammatory mass. This type of thrombosed hemorrhoid is frequently associated with thrombosis of the internal hemorrhoidal plexus and is perhaps treated more satisfactorily in the hospital. Occasionally, however, it may be possible to excise the hemorrhoidal masses under local anesthesia in an ambulatory patient.



Fig. 301. Thrombosed mixed hemorrhoids. External hemorrhoids are seen as the edematous skin covered area lying to the side. Thrombosed prolapsed masses of internal hemorrhoids appear in the center.

Internal Hemorrhoids

Etiology and Symptoms. Dilatation of the upper hemorrhoidal plexus is associated almost invariably with a looseness and a laxness of the mucous membrane just above the pectinate line It is a question not yet settled whether the dilatation of the hemorrhoidal vessels causes a stretching and a looseness of the overlying mucous membrane or whether the hypertrophy and the loose attachment of the mucous membrane offer such poor support for the underlying venous plexus as to permit it to become dilated. In any event, due to straining at stool, there is a distention of the hemorrhoidal mass and a bulging into the lumen of the anal canal. The passage of a hardened stool mass or the frequent straining in diarrhea traumatizes the pouting mucous membrane and causes it to bleed, and, frequently, the loose mucosa is dragged downward with the passage of the stool so that it prolapses through the external sphincter. In extreme cases, the mucosa of the entire upper portion of the anal canal may be everted as a crimson rosette outside the anal sphincter. This is especially likely to occur when the external sphincter is relaxed and the anal canal becomes a ring during the act of defecation. The bleeding in internal hemorrhoids comes not from the hemorrhoidal veins but from the capillaries and the arterioles of the traumatized mucous membrane which overlies them. The bleeding is bright red in color and may frequently be seen to appear in spurts. It may continue as long as the prolapsus exists, and even after the mucous membrane is replaced inside the anal canal, so that clots of blood are frequently found lying in the ampulla of the rectum in cases of well-developed in-

ternal hemorrhoids. In many patients, the prolapse appears not only at the time of bowel movements but also occurs spontaneously if the patient is on his feet for a time, or if he is exercising, or merely walking about. This troublesome symptom is most often noted in those in whom the external sphincter is relaxed. The symptoms of internal hemorrhoids, therefore, are bleeding and prolapse.

Thrombosed internal hemorrhoids occur less frequently than thrombosed external hemorrhoids. When thrombosis of internal hemorrhoids is seen, the hemorrhoids are usually of the mixed type (Fig. 301) and not the simple internal variety. However, it does occur in internal hemorrhoids, usually due to trauma with or without infection. They are palpated as masses bulging from the wall of the upper anal canal. As a rule, they are not as hard and firm as most thrombosed external hemorrhoids, they are rarely as tender, and the inflammatory reaction subsides if the bowel is put at rest by the use of a liquid diet for 3 or 4 days.

Diagnosis. The diagnosis of internal hemorrhoids may often be suspected if a careful history is taken. However, other lesions which produce bleeding from the rectum must be kept constantly in mind. Even the finding of internal hemorrhoids should not deter the physician from making a careful examination of the entire lower bowel; other lesions such as rectal polyp and carcinoma may cause bleeding from the rectum. It follows, therefore, that a diagnosis cannot always be made at the patient's first visit unless the bowel is sufficiently clean to permit such an examination to be made. Internal hemorrhoids may be suspected by digital palpation, but their presence can be made certain only by visual examination, which does not necessarily have to be made with instruments. In larger hemorrhoids with a relaxed external sphincter, by pulling apart the buttocks as the patient strains the mucous-membrane covered hemorrhoidal masses may often be seen presented at or prolapsed through the anal orifice. More definite knowledge can be obtained by examination with a lighted anoscope. With this instrument in place, the hemorrhoidal masses present into the scope and become more apparent as the patient strains. Often, as the hemorrhoidal mass is distended, bleeding will be seen to appear from the part of the hemorrhoid nearest the pectinate line, frequently in spurts from a superficially placed arterial vessel.

Treatment of Internal Hemorrhoids. When bleeding from internal hemorrhoids occurs only occasionally and is associated with periods of constipation or diarrhea, the hemorrhoidal masses are usually found to be so very small that ordinarily they give no symptoms. In such cases, it would seem logical to treat the underlying cause, namely, the constipation or the diarrhea, and often regulation of the patient's bowel habit will entirely relieve the local disturbance. As an associated therapy, various sorts of astringents and sedatives made into suppositories or ointments may be applied.

When the bleeding appears at frequent intervals, in spite of a well-regulated bowel habit, some more active form of therapy must be employed. In such cases, excellent results may be obtained by the injection of some irritating solution into the hemorrhoidal mass. The injection is not made directly into the hemorrhoidal vein but into the area of the dilated

hemorrhoidal plexus. The purpose of the solution is to set up an inflammatory reaction which will produce a thrombosis and secondary fibrosis so as to shrink up the hemorrhoidal mass and unite it more firmly to the underlying wall of the anal canal and the lower rectum.

TECHNIC OF INJECTION Injection is performed more conveniently with the patient in position on the proctoscopic table, although the knee-chest or the lateral position may be used. An anoscope is inserted to expose the hemorrhoidal mass. Either an end-opening or a lateral-opening scope may be used, we have found the Brinkerhoff type to be the most satisfactory. Internal hemorrhoids are usually found at three chief locations to the right of the mid-line posteriorly, to the right of the mid-line anteriorly and in the middle to the left lateral anal wall. As the patient strains, these hemorrhoidal projections may be easily visualized in the scope as distended masses covered with bright red mucous membrane. The injection is best made with a hemorrhoidal needle, a long needle bent so that the syringe is out of the field of vision, which permits a view of the hemorrhoid during the injection. The needle is pressed into the center of the hemorrhoidal mass (Fig. 302), the injection being made between the mucosa and the submucosa, and between the submucosa and the muscularis No attempt is made to inject any certain vessel, the injection is a

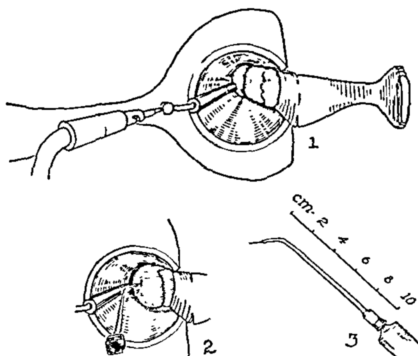


FIG. 302. (1) The internal hemorrhoidal mass appears in the lateral window of the Brinkerhoff anoscope as the patient strains. (2) The mass is injected at its mid-point, as near the upper edge as possible The Frankfeldt hemorrhoidal needle may be used; the author prefers Vail's tonsil needle with the injecting tip filed down to a length of 1/4 in. (3) Satisfactory type of needle.

perivenous rather than an intravenous one.

Any one of several solutions may be used: quinine and urea, 5 per cent; quinine hydrochloride, 13 per cent, with urethane, 6.5 per cent; and phenol, 5 per cent in almond oil. These are solutions in common use which have stood the test of time. The first two are injected in amounts up to 1 cc. and the last up to 2 cc. In using the phenol in oil, the injection should distend the hemorrhoidal mass evenly. In addition to these, the solutions used in the sclerosing of varicose veins may be employed. Sodium morrhuate, 5 per cent solution, or any of the other oily solutions, such as monoethanolamine morrhuate and sodium psylliate (Sylnasol), may be used in amounts of from 0.5 to 1 cc. One or several hemorrhoids may be injected at a time, depending upon the size and the distribution of the hemorrhoidal masses. If a good reaction is obtained from the first injection, the mucous membrane will feel tough and leathery, and it may be wise to delay further injection until the reaction has subsided. Usually, from 1 to 4 injections are necessary to treat a single hemorrhoid, and they are given at intervals of from 5 to 7 days. At times, the lower portion of the hemorrhoid may remain prominent, and in such cases an injection of 20 per cent phenol in equal parts of glycerin and water is given deeply into the center of the hemorrhoidal mass. Generally from 5 to 7 min. of this solution is injected, a vaccine syringe being used.

The injection treatment of hemorrhoids is one that can easily be carried out in the ambulatory patient; there is no particular pain incidental to the insertion of the needle into the insensitive mucous membrane. A very slight feeling of discomfort may be experienced at the time of the injection. Following injection, a sense of fullness may be felt in the lower rectum, but acute pain rarely occurs. Bleeding may continue for several days after injection, and the patient should be warned of this possibility. If pain occurs during or following an injection, the needle has been inserted too close to the mucocutaneous line.

By the injection treatment, practically all bleeding internal hemorrhoids and some bleeding hemorrhoids with minor degrees of prolapse may be treated successfully. One cannot promise that there will be no recurrence following this therapy, but the patient can be assured of relief from his bleeding, and, with normal attention to his bowel habits, the probability of recurrence is slight.

The injection treatment of internal hemorrhoids is contraindicated when the hemorrhoids prolapse, when there are other anal lesions which demand surgery, such as fissure or fistula, or when there is infection. External hemorrhoids are never treated by injection.

Hemorrhoidectomy. Internal hemorrhoids which prolapse are best treated by excision of the hemorrhoidal mass. When several large masses are present, hospital admission is preferable, but, in many cases with a single prolapsing mass, hemorrhoidectomy may be performed under local anesthesia in the ambulatory patient. In such cases, the entire circumference of the anal region does not have to be infiltrated to produce anesthesia sufficient for excision of the hemorrhoid. Usually, the infiltration is confined to the skin area and the underlying tissues in the region of the hemorrhoid. With the patient either

in position on the proctoscopic table or in the lateral position, the anesthetic is injected and the hemorrhoid is brought into view with Allis forceps. A suture is then placed round the base of the hemorrhoid, fine chromic or plain catgut being used; this is tied and the ends are left long for use as a tractor. With traction on the ligature, upon an Allis forceps over the middle of the hemorrhoid and on the skin surface, the entire amount of hypertrophic tissue may easily be demonstrated. This is excised with scissors or scalpel, the mucous membrane being united by interrupted sutures of fine gut. By this method any bleeding is controlled. The ends of the sutures are left long and grasped in a hemostat, so that by traction upon them the entire

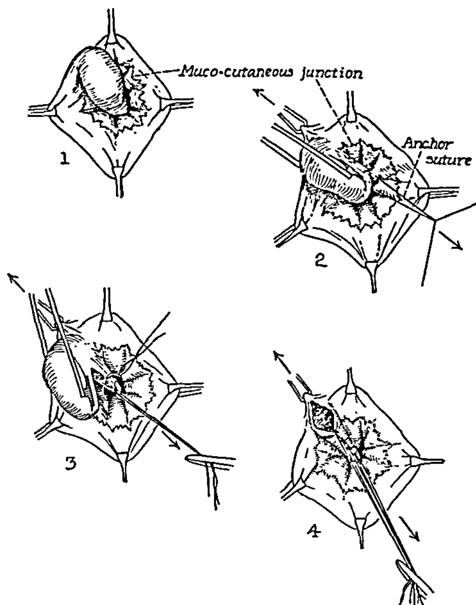


FIG. 303. Hemorrhoidectomy. (1) Hemorrhoid exposed. (2) Suture ligature placed. (3) Excision started, the second suture having been placed. (4) Suturing almost complete.

wound can be visualized throughout the operation. After the excision has reached the mucocutaneous junction, a wedge-shaped area of skin and subcutaneous tissue is excised; this extends the incision a distance of about ¾ in. lateral to the anal margin. No sutures are inserted into the skin. A simple pressure dressing of gauze is inserted into the wound and a T-binder is applied, the ligatures being cut off fairly long (about 1 in.). (Fig. 303)

These patients may be permitted to go home after such an operation; they are given 6 tablets of ⅛ gr. morphine sulfate and instructed to take one every 3 hours as needed for pain. The dressings may be removed and replaced as necessary, and, after the first 24 hours, hot sitz baths are advised 3 or 4 times a day. Usually, a liquid diet is suggested for at least 2 days. As a rule, the wounds heal very kindly. The frequent postoperative complication of urinary retention is almost never seen in the ambulatory patient.

RECTAL PROLAPSE

Definition. By a prolapse of the rectum is meant an eversion of the bowel through the anal orifice. The prolapse may consist of the mucous membrane only or of all the walls of the rectum. It is important to make a differentiation between these two types of prolapse, because one may be easily treated in the ambulatory patient, whereas the true prolapse of all the rectal coats usually demands hospitalization.

Prolapse of the Rectal Mucosa (Incomplete Prolapse)

Etiology. The mucous membrane of the lower rectum is attached rather loosely to the underlying submucosa, and in some instances, especially in young children and in old people, this attachment may be so loose as to permit the prolapse of the mucous membrane through the anal orifice. The cause of this prolapse may be wasting diseases, straining or diarrhea. In older people, a sphincter relaxation frequently is found to be a causative factor.

Symptoms. The prolapsed mucosa appears as a doughnut-shaped mucosal ring at the anal orifice which protrudes usually at the time of defecation. It may disappear spontaneously, or it may have to be replaced digitally. In older people with sphincter relaxation, the slightest strain, or even simply being up and about, may produce a prolapse of the mucous membrane. The symptoms produced by the prolapse are usually not marked. It is the appearance of the mass at the anal orifice which worries mothers of children with prolapse. There is usually a slight amount of mucous discharge and moisture of the surrounding buttocks. Abrasion by clothing causes slight bleeding, and the presence of the mass at the anal orifice often produces incomplete and difficult evacuation.

Diagnosis. On examination one finds the prolasped mucosa extending at most about 1 in. from the anal orifice. The examining finger, placed round the outer edge of the mucosal ring, meets at once the anorectal line, where the prolapse ends laterally. The finger may be inserted through the anal canal into the lower rectum.

Incomplete prolapse must be differentiated from prolapsed internal hemorrhoids and from a true prolapse of all the coats of the rectum. As a rule, the prolapsed internal hemorrhoids appear in 2 or 3 rather pronounced masses (Fig. 301), and there is an asso-

ciated edema of the perianal skin. Usually, the underlying venous plexus is thrombosed, so that reduction of the prolapse is performed with some difficulty. The treatment of the prolapsed internal hemorrhoids is hemorrhoidectomy (see section on hemorrhoids). In differentiating prolapse of the rectal mucous membrane from a true prolapse of all the rectal coats, the chief distinguishing features are the marked thickness of the complete prolapse, as compared with the relatively thin appearance of mucous membrane prolapse, and the circular corrugations characteristic of prolapse of the entire rectal wall as it protrudes from the anal orifice.

Treatment of Incomplete Prolapse in Children and Infants. In this group conservative therapy is frequently sufficient to effect a cure. The general nutrition of the child should be improved as far as possible by an adequate diet and sufficient vitamins. Local therapy consists of reducing the prolapsed mucosa after each stool and then strapping the buttocks together with adhesive tape. It is well to keep the child in bed for at least a week and to evacuate the bowels with a small enema (about ½ pint) with the child lying so that the buttocks are over the side of the bed. It is important to avoid straining as much as possible, and, for some time after the child is allowed up, the use of a lavatory seat or a chamber is to be avoided; evacuation should be performed in the squatting position over a tray.

If this type of therapy is unsuccessful, injection therapy may be used. With the child in the lateral position, an irritating solution is injected through the mucous membrane into the submucosal area through an anal speculum, which may be introduced without danger even in very young children. Terrell[17] uses quinine and urea hydrochloride, 2.5 to 3 per cent solution, depositing a few drops in 3 or 4 points above the anorectal line. Daniels[3] uses from 10 to 15 cc. of 5 per cent phenol in sweet almond oil. Morley[10] and Lockhart-Mummery[9] use the same solution, but Lockhart-Mummery does not inject more than a total of 4 cc. in children, depositing it in 1 anterior and 2 lateral injections. Usually, only one or, at most, 2 injections are necessary. After injection, the area is massaged gently with the gloved finger. The patient should be kept in bed for several days and defecation carried out with the patient on his back.

Treatment of Incomplete Prolapse in the Aged. After a cleansing enema, the patient is placed in the knee-chest position or on the proctoscopic table, and an anoscope is introduced into the lower rectum. Injections are then made into the area between the mucosa and the submucosa, about 3 cc. of 5 per cent phenol and almond oil being introduced in 3 areas round the rectal circumference. The injection may be made without pain, and the patient should be sent home to bed for 2 or 3 days. A liquid diet is prescribed to reduce the tendency to bowel movements for a period. After 3 days, an enema is given and the bowel contents are evacuated while the patient lies in bed. Every effort should be made to prevent straining at the stools. An enema every other day usually will accomplish this. Lockhart-Mummery[9] recommends that the patient be instructed to wear a piece of rubber tubing attached to a belt at back and front. This will exert pressure over the anus and tend to prevent prolapse. If the first attempt

to cure the prolapse by injection is unsuccessful, a second injection may be given after 1 or 2 weeks.

Rectal Prolapse Associated with Rectal Polyp

Frequently in children and less commonly in adults, prolapse of the rectum or of the rectal mucosa may be produced by the dragging and the pulling of a pedunculated polyp upon the mucous membrane. In such cases, there is usually a history of pain associated with bowel movements and, frequently, bleeding. There is then a prolapse of the mucous membrane with each movement, and on examination the prolapse is found to contain a pedunculated rectal polyp. The frequency of this association of prolapse and pedunculated polyp makes it necessary to examine digitally each case of prolapse, especially in children, in order to determine whether or not a polyp is present; it is easily identified as a small globular movable mass within the rectal lumen.

Treatment. In these cases, removal of the polyp by electrocoagulation of the base of the pedicle usually cures not only the polyp but also the associated prolapse. This procedure (see pp. 416-417) can be carried out without anesthesia and without hospitalization even in children.

When conservative measures or injection therapy fails to effect a cure in incomplete prolapse of the rectum, hospitalization is usually required for more radical procedures. All these require anesthesia and bed rest and, therefore, are not suited to ambulatory care.

Complete Rectal Prolapse

Complete rectal prolapse is usually a disease of adult life. As a rule, it is not suitable for ambulatory care because relatively radical operations may be necessary to effect a cure. It may be necessary, however, to attempt to reduce a rectal prolapse in the home. In such circumstances, the prolapsed mass is usually large, often some 4 or 5 inches in length, and the history is that prolapse occurred on many previous occasions. Frequently, by the time the physician is called, the condition has existed for some hours and the tissues are blue or purplish in color, due to constriction of the sphincter muscles and the patient's ineffectual efforts to reduce the prolapse.

Treatment. It is important that early reduction of the mass be accomplished if possible. This may be performed by following out carefully a very definite technic. A moist towel or gauze is placed about the prolapse and the protruding mass is squeezed gently between both hands in an effort to reduce the edema and venous congestion. The gentle pressure is continued for some time, the patient lying on the left side with both knees drawn up. Then, holding the mass in both hands, the thumbs are covered with wisps of cotton or small pieces of toilet tissue and pressure is made at the apex of the mass. With patience, the mass begans to get smaller, and, by working from the apex backward, the whole protrusion may be replaced within the anal orifice. After the mass is reduced, a large-sized rubber tube, from 6 to 8 in. long, should be passed into the rectum and secured with a safety pin and a T-binder. This will prevent immediate recurrence of the prolapse and will afford time for the patient to be studied and for a decision to be made as to the best procedure.

FECAL IMPACTION

Fecal impaction is probably the commonest cause of diarrhea in older people. At the Proctoscopic Clinic at the Philadelphia General Hospital, about half of the patients who give a history of diarrhea are found to have masses of retained feces. These cause intermittent diarrhea and constipation, with a sense of marked pressure in the lower rectum. The diagnosis is easily made by inserting the gloved finger into the lower bowel, where the hard fecal mass is palpated.

Treatment. Usually, repeated digital attempts at breaking up the mass are necessary for complete and successful evacuation. This is best done with the patient lying on the side. After each digital manipulation, an enema is given to remove what fecal material has been broken loose. This procedure is repeated twice daily until the mass has been completely evacuated.

Cathartics do not take the place of this method of treatment. Warm oil enemas are usually of little value unless assisted by a digital breaking-up of the mass, and with it they are not necessary. A small amount of peroxide of hydrogen, introduced into the bowel, is sometimes beneficial. After evacuation of the impaction, the patient should be watched carefully to prevent recurrence.

RELIEF OF PAIN AFTER ANAL OPERATIONS

Various methods have been suggested for the relief of pain after anal operations. This applies to ambulatory patients following the excision of thrombosed external hemorrhoids, fissure operations, hemorrhoidectomies and even incision and drainage of acute inflammatory lesions such as perirectal abscess. Topical applications of ointments containing local anesthetics, such as Diothane and Nupercaine, have been used with rather mediocre results. They are better than plain gauze, but they do not give the relief of pain that might be expected in cutaneous wounds.

A new topical anesthetic agent[12,14,17] —paramoxine hydrochloride (Tronothane Hydrochloride, Abbott)—offers considerable promise for relieving pain after anal operations. It is supplied in a 1 per cent jelly or cream in a water-soluble base and is applied directly to the operative site before application of the dressings. It apparently has low indices of sensitivity and toxicity.

After a considerable trial with various methods of relieving pain following anal operations, the author has reached some definite conclusions. Pain is due to a traumatic irritation at the operative site. This irritation may be held to a minimum if mucosal or skin approximation can at least be partially effected. The traumatic irritation of the wound site causes a secondary spasm of the anal sphincter; this is most marked at the time of bowel movement. The sphincter spasm grasps and squeezes the traumatic wound and so prolongs the pain after bowel movement. Applications of moist heat (hot compresses or hot sitz baths) are the most effective way to relax anal spasm and relieve anal pain. They should be used after each bowel movement and at least 4 times daily.

There is a general idea that the softer the stool the less pain the patient will experience after anal operations. This is true up to a point. A hard dry stool produces discomfort

in its passage even without an operative wound On the other hand, more trauma and a worse inflammatory reaction are caused by soiling in the operative wound by frequent loose or watery stools than is caused by a firm formed stool. One daily formed stool should be the aim Usually, a cathartic is not advisable; mineral oil may be used as necessary.

The long-acting oil-soluble anesthetics would seem to be ideal for use after anal operations. After a considerable experience with them, the author has given them up completely. They are not necessary if the above suggested plan of postoperative care is followed, and even with the most careful technic there is the danger of necrosis and slough which are much more difficult to endure and treat than is the pain from an anal operation

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The Genito-urinary System

HARRY M. BURROS*

Many urologic disorders may be handled on an ambulatory basis. These include conditions that may be controlled completely by outpatient care and others that subsequently may require hospitalization for definitive therapy. The discussion is approached best by consideration of two categories—urologic emergencies and subsequent outpatient care. In dealing initially with patients in either group, a careful history and physical examination are of basic importance.

UROLOGIC EXAMINATION

The urologic history should elicit information concerning the following symptoms: (1) pain—costovertebral angle, lumbar, suprapubic, perineal, genital, rectal; (2) urinary symptoms—frequency (both diurnal and nocturnal), dysuria (before, during or after voiding), oliguria, anuria, polyuria, hematuria (initial, terminal or total); (3) tumor—costovertebral angle swelling, suprapubic swelling, scrotal swelling; (4) signs of infection—fever, chills, cloudy urine, malaise; and (5) incontinence.

In examining the patient with possible disease of the genito-urinary tract, a systematic review should be performed. Renal tenderness can best be elicited by fist percussion. With the patient seated in his normal position, the examiner, standing behind him, percusses gently but firmly with even strokes from the lower thorax to the iliac crest on each side (Fig. 304). With the patient in the supine position, both tenderness and masses in the kidney region may be found by bimanual examination. On the right side, this is best accomplished by the examiner's standing on this side of the patient and placing his right hand anteriorly and his left hand on the costovertebral angle. The left side is examined in a similar manner after the examiner has moved to the left of the patient.

After deep inspiration, the lower pole of the kidney normally may be felt in thin individuals (Fig. 305) Ureteral tenderness is tested for by deep anterior lateral abdominal palpation. Suprapubic masses and tenderness are checked by both palpation and percussion in the area between the umbilicus and the symphysis pubis. Palpation of the scrotum and its contents should determine the size, the shape and the consistency of the testicle, the epididymis, the vas deferens and the spermatic cord. Comparison should always be made of the two sides The prostate gland and the seminal vesicles are palpated with the patient in the knee-chest position, although it is satisfactory to have the

* Associate in Urology, Graduate School of Medicine, University of Pennsylvania.

patient stand and rest his hands on a low table or chair. With the finger inserted far into the rectum, systematic examination is made: first, posteriorly, for rectal masses; then, anteriorly, over the entire prostate region. The size of the prostate is described in grades from 1 to 4 (Figs. 306-310). Usually, the normal seminal vesicle cannot be palpated. The prostate is examined for normal or abnormal architecture, including the presence or the absence of the median sulcus and the lateral borders, for consistency, whether hard, soft or normal; for tenderness, and if any is found, its degree and in what part of the gland it is located; for the presence or the absence of nodules; for mobility or fixation and symmetry.

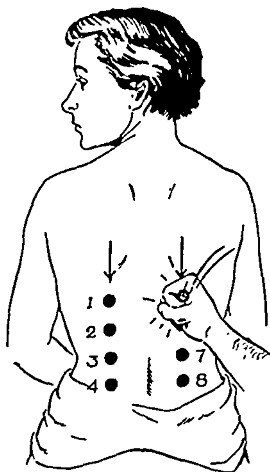


Fig. 304. Technic for determining costovertebral angle tenderness

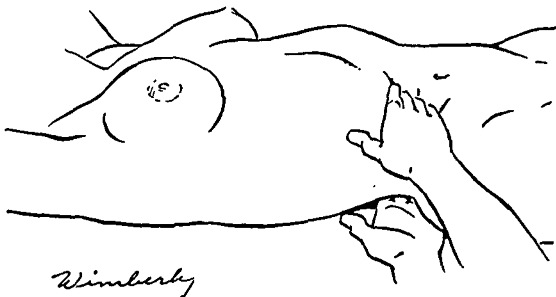


Fig. 305. Technic for palpating the kidney.

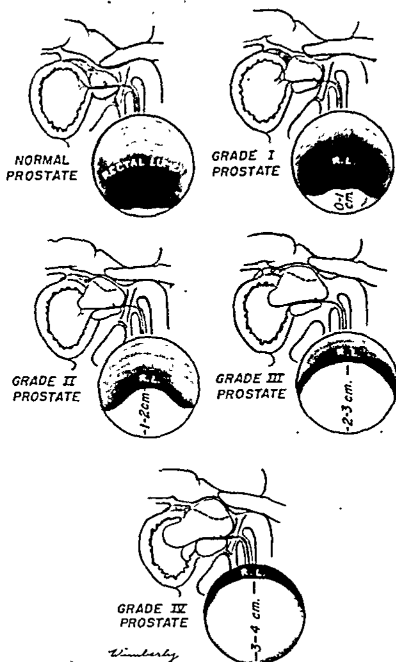


Fig. 306. Normal prostate as palpated by rectum. Practically no projection into rectum. Inset shows cross section of findings by palpation.

Fig 307. Grade I enlargement of prostate as palpated by rectum. Prostate encroaches into rectal lumen approximately 0 to 1 cm.

Fig. 308. Grade II enlargement as palpated by rectum. Prostate encroaches into rectal lumen from 1 to 2 cm.

Fig. 309. Grade III enlargement as palpated by rectum. Prostate encroaches into rectal lumen from 2 to 3 cm.

Fig. 310. Grade IV enlargement as palpated by rectum. Prostate fills almost entire rectum, being elevated more than 3 cm. above its floor.

(Figs. 306-310 *from* Barnes, Roger W.: Endoscopic Prostate Surgery, St. Louis, Mosby)

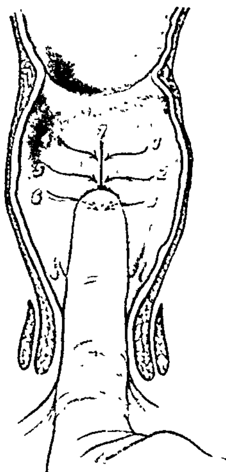


FIG. 311. Technic of prostatic massage

If, from previous history and physical examination, the prostate is thought to be involved in any way in the disease process, a prostatic massage should be done to obtain secretion for microscopic examination. This is carried out by using pressure of the index finger, starting laterally at the superior pole on each side and moving the finger toward the mid-line with each stroke. (Fig. 311.)

EMERGENCIES

Urologic emergencies are encountered in all age groups. In many of these, hospitalization is required, but in a fair number treatment may be carried out satisfactorily in the office or the dispensary.

ACUTE OBSTRUCTIONS

Stenosis of Meatus

Congenital narrowing of the urinary meatus in the male is a common cause of obstruction. Meatal stenosis also may be seen in the adult as a result of previous infection. Meatotomy must be performed to correct this condition (Fig. 312.)

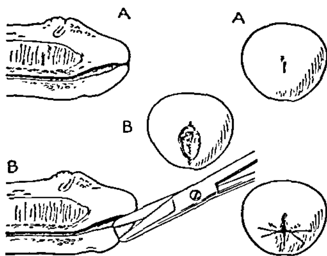


FIG. 312. Technic of meatotomy. (A) Sagittal section and front view of narrow meatus (B) Sagittal and front views of meatal incision (C) Urethral mucosa and skin united by catgut sutures. (Figs 312, 319, 320 and 323-330 *from* Rolnick, H.C.: The Practice of Urology, Philadelphia, Lippincott)

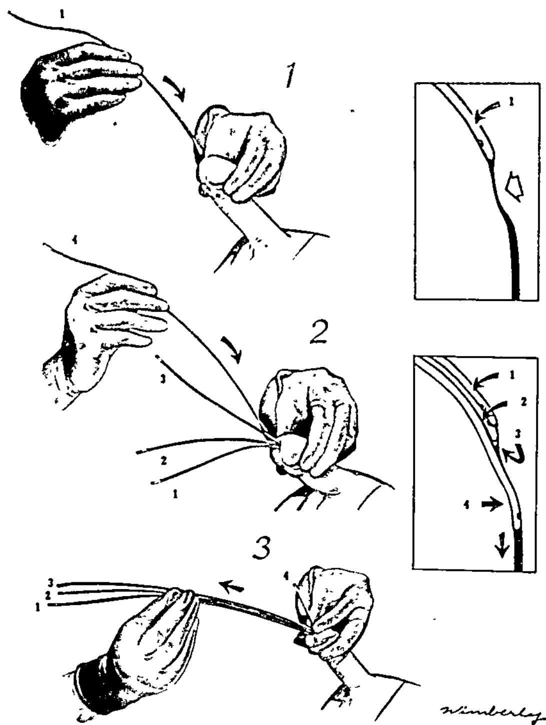


FIG. 313. Technic of by-passing a stricture using multiple filiforms *(Continued on following page)*

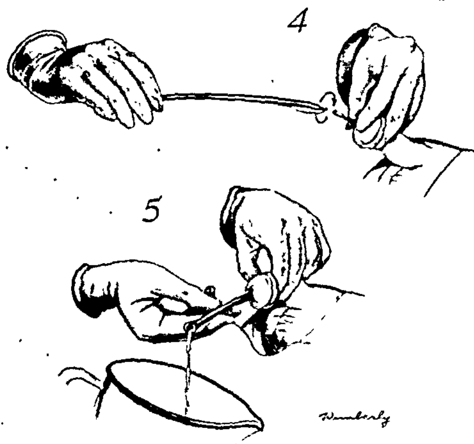


Fig 318 (*Continued from preceding page*). Technic of by-passing a stricture using multiple filiforms.

Urethral Stricture

Strictures of the urethra are caused by gonococcal infection or prior trauma. Usually, the condition is found in a younger age group than is prostatic hypertrophy. There may be a history of *previous* gonorrheal infection, this manifests itself by progressive *narrowing* of the urinary *stream and, occasionally*, by a forked *or a deviated* stream. A history of *previous urethral* instrumentation also should lead one to suspect the presence of a stricture. Pain is not a common symptom in this entity. The diagnosis may be made by passage of a simple straight rubber catheter. If the catheter obviously is blocked in the anterior or the mid-urethra, the presence of urethral stricture is suspected. If the block is encountered in the membranous or the posterior urethra, the diagnosis must be made between stricture and prostatic hypertrophy, and other methods of examination must be used.

The purpose of the immediate treatment is to relieve the urinary retention and dilate the urethra enough to keep the patient on an ambulatory basis and allow him to return for follow-up therapy. The glans penis is cleansed with tincture of green soap and bichloride of mercury solution 1:1,000. Then a filiform is passed through the urethra, and into the

bladder if possible. If obstruction is encountered, and if manipulation of the filiform does not succeed in bypassing the strictured area, multiple filiforms must be used as demonstrated. (Fig. 313.)

One method that has proved to be useful in difficult cases is to fill the urethra with sterile mineral, cottonseed or olive oil. With the thumb and the forefinger holding the oil in the urethra, the filiform is passed through the dilated urethra and then on into the bladder. After the filiform has been introduced, a suitable follower (Phillip's or LeFort's—Fig. 314) is attached and inserted through the stricture to dilate this area. If further attempts at manipulation are unsuccessful by the use of filiforms, then the patient should be hospitalized for dilatation under anesthesia or, in rare cases, for internal or external urethrotomy.

Prostatic Hypertrophy

Prostatic obstruction may result in either acute or chronic urinary retention. Acute obstruction is characterized by suprapubic pain, and a suprapubic mass which is palpable. The percussion note in this area is dull or flat. On the other hand, chronic obstruction usually is unassociated with any pain, even though the bladder may be enlarged tremendously. The patient in either group often will give a history of frequency of urination

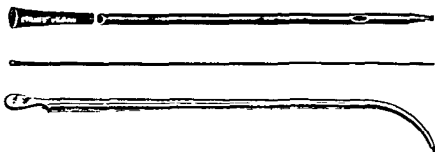


Fig. 314. (*Top*) Phillip's woven urethral catheter threaded for woven filiform; sizes 8 to 28 F should be available. (*Center*) Woven filiform threaded for Phillip's woven urethral catheter or Le Fort metal sound. (*Bottom*) Le Fort metal sound threaded for woven filiform; sizes 8 to 28 F should be available. (C. R. Bard, Inc., New York)

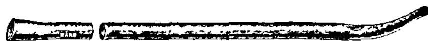


Fig. 315. Solid-tip rubber urethral catheter. Tiemann demirigid catheter. (C R. Bard, Inc., New York)

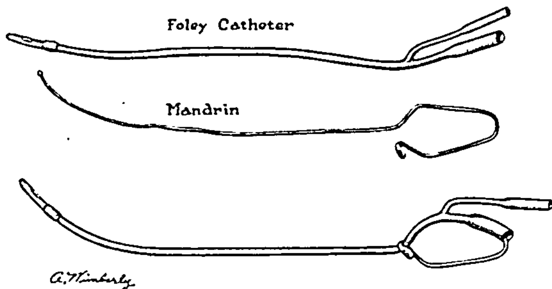
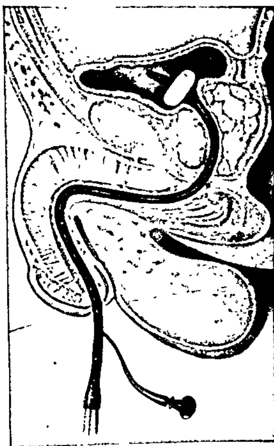


FIG 316 Foley catheter and mandrin before assembling (*top* and *center*) and assembled (*bottom*).



both day and night, of narrowing of the urinary stream; of loss of force; of dysuria; of difficulty in starting the stream and of overflow incontinence. All these symptoms will help to establish the diagnosis of bladder-neck obstruction.

Initial therapy for the two types of urinary retention is quite different In the acute type of retention, the bladder should be emptied completely by simple catheterization, if possible. If this fails, a very satisfactory type of catheter which will prove to be effective is the hard rubber olive-tipped Coudé curve (Fig. 315). If it is desirable to maintain con-

FIG. 317. Self-retaining urethral catheter with a 5-cc. balloon. The catheter is made self-retaining after insertion into the bladder by distending the balloon with 5 cc. of water This is the ideal indwelling catheter for either male or female. (C. R. Bard, Inc., New York)

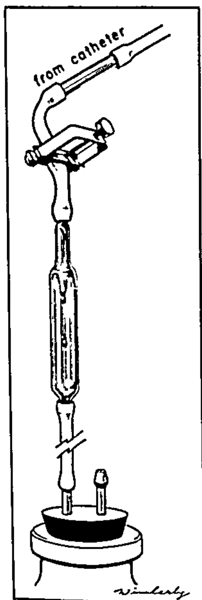
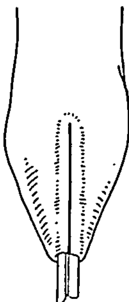


Fig. 318 (*Left*). Murphy drip technic of decompressing bladder.



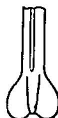
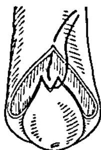


Fig. 319 (*Right, top*). A grooved director is inserted under the prepuce to the corona; then the prepuce is divided along the director with a pair of pointed scissors.



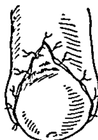


Fig. 320 (*Right, bottom*). Edges of dorsal slit united with interrupted sutures of fine chromic catgut.

tinuous drainage of the bladder following catheterization, a Foley catheter with the use of a metal mandrin may be used (Figs. 316-317). Some newer types of Foley catheters now are manufactured; these are of a harder rubber and are made with a Coudé curve. They may be used in selected cases. In chronic urinary retention, treatment should not be undertaken on an out-patient basis because sudden decompression of the bladder may lead to serious consequences, such as hemorrhage from the urinary tract and shock. If it is necessary to catheterize these patients because of the inaccessibility of a hospital, the bladder should be decompressed gradually. This can be done by intermittent drainage of small amounts (e.g. 100 cc. every hour), or a Murphy drip may be attached and approximately 60 to 80 drops a minute allowed to drain from the bladder (Fig. 318).

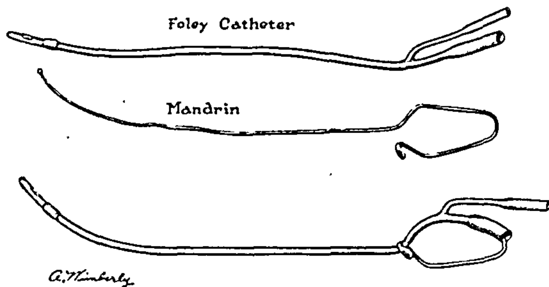
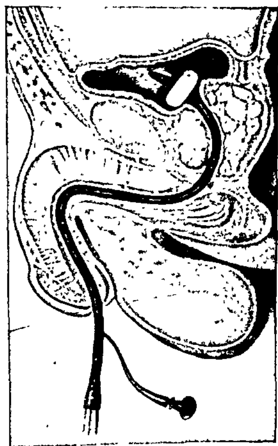


Fig 316. Foley catheter and mandrin before assembling (*top* and *center*) and assembled (*bottom*).



both day and night; of narrowing of the urinary stream; of loss of force; of dysuria; of difficulty in starting the stream and of overflow incontinence. All these symptoms will help to establish the diagnosis of bladder-neck obstruction.

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Fig. 317. Self-retaining urethral catheter with a 5-cc. balloon. The catheter is made self-retaining after insertion into the bladder by distending the balloon with 5 cc. of water. This is the ideal indwelling catheter for either male or female. (C. R. Bard, Inc., New York)

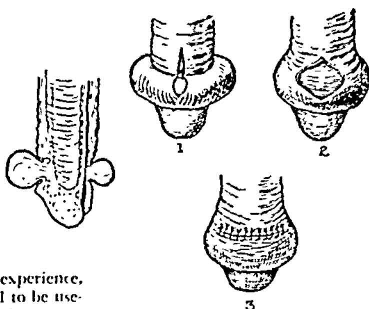


Fig. 322. Dorsal slit for relief of paraphimosis. (1) Incision of the constricting preputial ring. (2) Appearance after severing the constricting bands. (3) Closure of the skin in transverse manner.

atous area. In our own experience, we have found this method to be useful and effective, and use it now to the exclusion of other therapy.

Neurogenic Disturbances

In dealing with a patient complaining of urinary obstruction, one must consider the possibility of a neurologic lesion which has affected the function. The symptoms may simulate those of obstruction due to other causes, such as described above. The mere presence of an overdistended bladder, therefore, does not mean necessarily obstruction at the bladder neck. Such diseases as tabes dorsalis, multiple sclerosis, tumors of the spinal cord or cerebral lesions must be considered if another diagnosis is not obvious. In these disorders hospitalization usually is required for complete evaluation and definitive care, but it sometimes is necessary as a temporary measure to catheterize a patient who presents symptoms of urinary retention.

Anuria

The symptoms of inability to void may be due also to anuria. If a catheter is passed and no urine is obtained, a simple test should be made to determine if the catheter is in the bladder and if it is patent. A measured amount of fluid is injected through the catheter by means of an Asepto syringe. If the same amount as was injected is withdrawn, the catheter is placed properly and the diagnosis is anuria. Then the locus is established as upper urinary tract or extrarenal, and the patient should be hospitalized.

Common Lesions of the Genito-Urinary Tract Causing Pain

Pain referable to any part of the genito-urinary tract is one of the commonest symptoms for which a patient seeks medical attention.

Renal Colic

The typical pain due to renal colic may be described best as starting at the costovertebral angle (lumbar region) and radiating down the course of the ureter to the groin, occasionally into the testicle, the vulva or the thigh. This pain often is extremely

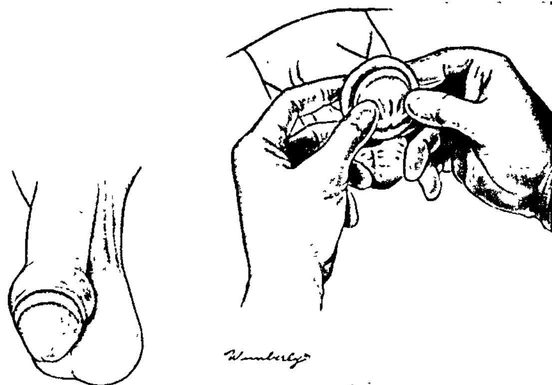


Fig. 321 Reduction of paraphimosis.

Acute or chronic urinary retention is a sign of serious disorder of the bladder or the bladder neck. It is imperative that these patients be hospitalized for further study following emergency treatment.

Phimosis and Paraphimosis

Phimosis is a narrowing of the opening of the distal end of the foreskin which prevents its retraction behind the glans. Paraphimosis occurs when the foreskin is behind the glans and cannot be brought forward because of constrictive bands or edema. Phimosis may require emergency treatment if it is causing urinary retention. Dorsal slit is the operation of choice for immediate relief (Figs. 319-320). Circumcision should be performed at a later date (Fig. 331). Numerous treatments have been described for the reduction of paraphimosis. The simplest procedure and the one that should be tried first is reduction by manual compression. This is illustrated in Figure 321 and is effective in a majority of cases. If this is not succesful, dorsal slit also may be used effectively (Fig. 322). T. H. Williams and R. K. Nichols[6] reported a method of treating paraphimosis using hyaluronidase. They believed that this method should be used first. Using 150 turbidity reducing units of hyaluronidase (Wydase) in 2 cc. normal saline solution, injection was made round the constricting band. In 15 minutes the constriction reduced spontaneously. R. K Ratliff[4] in a later report, showed similar results, injecting only at three o'clock and nine o'clock in the edem-

As a rule, this pain can usually be alleviated by milder medication, such as codeine and aspirin. The treatment of the infection is discussed later in this chapter.

Ptosis

Pain due to ptosis of the kidney has been described over the years and is known as Dietl's crisis. Classically, the pain is worse on standing and is relieved on lying down. The characteristic findings are failure of the renal pelvis to empty in the erect position (as seen on intravenous urogram), infection demonstrated by culture in a ptotic kidney and signs of pyelectasis and/or caliectasis due to kinking of

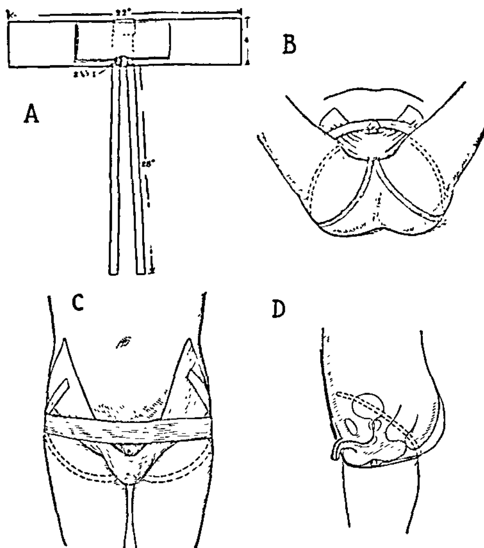


FIG 323 Scrotal support. (A) Dimensions of adhesive plaster and roller bandage. (B) Roller bandage placed high in the scrotoperineal angle; the lower straps are brought over the hips, the broad strap over the iliac crests. (C) Front view of roller bandage of scrotum. An additional cross strap of adhesive reinforces the dressing (D) Scrotum supported by dressing.

severe, it may be intermittent or constant, and it is caused mainly by the increased pressure within the renal pelvis. The relief of this pain may be attempted by various methods. Morphine sulfate gr. ¼ combined with atropine sulfate gr. $^1/_{150}$ is the commonest drug used. Atropine alone is of no beneficial effect, but it acts to antagonize the constricting effects of morphine. Demerol in doses of 100 mg. also is effective. Probanthine 15 or 30 mg. by mouth has been used successfully. In severe cases, intravenous Probanthine (30 mg. dissolved in 10 cc. of sterile water or saline) is useful. This is injected over a period of approximately 5 minutes.

Acute Retention

The pain of acute urinary retention is centered mainly in the suprapubic area, and in the male it is referred down to the tip of the penis. Morphine and atropine or Demerol are again good drugs to alleviate this pain, but the only definitive relief is obtained by catheterization. This has been described above.

Acute Epididymitis and Torsion of the Testis

Acute epididymitis and torsion of the testis are mentioned together because they are often confused. The former results from previous infection higher in the genito-urinary tract or from hematogenous spread. The usual causative factors are gonorrheal infection, chronic or acute prostatitis, seminal vesiculitis or recent urethral instrumentation.

Torsion of the testicle results from an anomaly in which the tunica vaginalis surrounds the epididymis completely as compared with the normal state in which the epididymis is covered only partially. This leaves the testicle suspended free in the vaginal sac and predisposes to twisting of the spermatic cord. When this occurs, gangrene of the testis is the ultimate result. Therefore, it is considered a surgical emergency. Points in the differential diagnosis are outlined as follows:

Acute Epididymitis

1. Onset gradual
2. Previous infection
3. *Tender*
4. Palpation reveals swollen epididymis and normal testis
5. Fever
6. Leukocytosis

Acute Torsion

1. Onset sudden
2. Usually no previous infection
3. Exquisite pain
4. Palpation usually cannot be done because of pain. If examination is possible, testicle enlarged and tender
5. Normal temperature
6. No leukocytosis

The treatment of epididymitis consists of relief of pain with analgesics, scrotal support (Fig. 323) and application of an ice bag initially. Hot sitz baths are used after the acute phase has subsided. Penicillin and sulfonamides usually are sufficient to control the infection. Torsion of the testicle requires immediate hospitalization and surgery.

Pyelonephritis

The pain of pyelonephritis usually is not severe. It follows the same course as the pain of renal colic, but generally it is much duller and is accompanied by symptoms of infection

As a rule, this pain can usually be alleviated by milder medication, such as codeine and aspirin. The treatment of the infection is discussed later in this chapter.

Ptosis

Pain due to ptosis of the kidney has been described over the years and is known as Dietl's crisis. Classically, the pain is worse on standing and is relieved on lying down. The characteristic findings are failure of the renal pelvis to empty in the erect position (as seen on intravenous urogram), infection demonstrated by culture in a ptotic kidney and signs of pyelectasis and or caliectasis due to kinking of

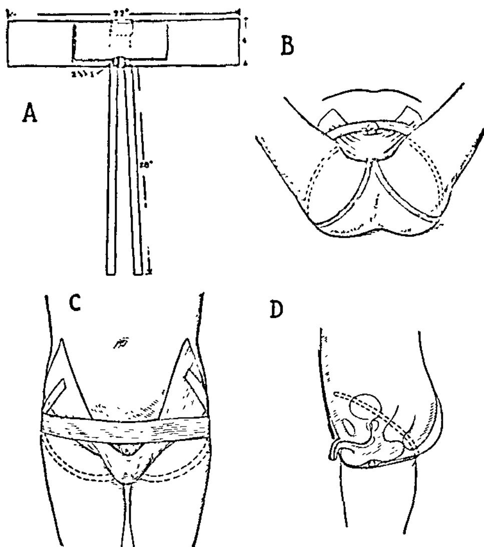


Fig 323 Scrotal support (A) Dimensions of adhesive plaster and roller bandage. (B) Roller bandage placed high in the scrotoperineal angle, the lower straps are brought over the hips, the broad strap over the iliac crests. (C) Front view of roller bandage of scrotum An additional cross strap of adhesive reinforces the dressing (D) Scrotum supported by dressing.

the ureter. After initial treatment of the acute symptoms with analgesics or narcotics, therapy is directed toward correction of ptosis itself. In some cases, the gaining of weight or the use of an abdominal support may be effective. However, the condition usually requires nephropexy.

Common Lesions of the Genito-urinary Tract Causing Bleeding

Painless bleeding from the urinary tract may be due to a variety of causes. The most common are calculus, tumor and tuberculosis. Complete urologic study is necessary, and treatment should not be considered in patients complaining of this symptom until diagnosis is established. There is no medication known that can cure hematuria. Extensive study also is required in cases of painful hematuria. Pain in the bladder area accompanied by hematuria suggests acute cystitis and/or acute prostatitis. Bleeding with pain in the costovertebral angle or the ureteral area usually has its origin in a stone in the kidney or the ureter. However, the mere passage of a blood clot, possibly due to tumor above, will give identical symptoms.

Initial hematuria (blood appearing at the beginning of micturition) in males is due chiefly to a lesion in the anterior urethra. In females, trigonitis and urethritis are the usual causes. Terminal hematuria (blood appearing at the end of micturition) is characteristic of disease of the prostate gland. Postcoital bleeding is a fairly common complaint of patients with prostatic congestion or infection. Treatment usually is prostatic massage at weekly intervals and antibiotic therapy.

Bleeding throughout the course of the urinary stream indicates a pathologic process either in the bladder or above it. Ambulatory treatment should not be considered. Massive uncontrollable hemorrhage from the urinary tract requires immediate hospitalization. Causes may be ruptured varix of the bladder or the kidney, tumors of the kidney or of the ureter or the bladder. Prostatic bleeding also may be massive with resultant clots in the bladder which must be evacuated.

Trauma

Trauma to the genito-urinary tract usually requires hospital care, and the only ambulatory treatment is the emergency care of the wounds. Milder injuries may be treated on an outpatient basis. For example, injuries to the external genitalia which involve lacerations only are sutured as are lacerations elsewhere in the body. Avulsions should be débrided and a sterile dressing applied. Scrotal hematoma caused by injury to the testicle recently has been treated by use of hyaluronidase. G. Axler[1] claims that injection of hyaluronidase solution causes rapid resorption of the extravasated blood with alleviation of the pain. The method is simple. The urea is prepared with an antiseptic solution, and local anesthesia consisting of 1 per cent procaine is injected into the area to be aspirated. The solution is prepared by combining 300 turbidity reducing units of hyaluronidase, 300,000 units of aqueous crystalline penicillin and 5 cc. of 1 per cent procaine. Saline is added to make a total volume of from 30 to 50 cubic cm. of solution. This is injected into the hematoma, and a tight suspensory is applied and left in place for approximately 1 day.

OUTPATIENT CARE IN URINARY TRACT INFECTIONS

Very often urinary tract infections are secondary to other more serious pathologic processes in the genitourinary system. In addition, many of these patients are not suitable for outpatient care, as they may require more intensive and complicated therapy and diagnostic studies.

Symptoms alone are not sufficient to make a diagnosis of urinary tract infection.[3] The presence of bacteria and/or leukocytes in the urine is necessary. Careful examination of the urine must be done in all suspected cases. Cloudy urine does not indicate infection, because crystals may produce this sign. The finding of bacteria or pus cells microscopically justifies the diagnosis of infection, although the presence of an occasional white cell may be considered to be normal. Treatment should not be undertaken without at least a gram stain, or, if possible, a culture of the urine. While awaiting culture, treatment may be started. The organisms most commonly found in the urinary tract according to their gram stain are:

GRAM NEGATIVE

1. *Escherichia coli*
2. *Aerobacter aerogenes*
3. *Proteus vulgaris*
4. *Pseudomonas aeruginosa*
5. *Alcaligenes faecalis*
6. *Paracolon bacillus*

GRAM POSITIVE

1. *Streptococcus faecalis*
2. *Streptococcus (hemolyticus* and *nonhemolyticus)*
3. *Staphylococcus (albus* and *aureus)*

The most common is *Esch. coli*, which is the most responsive to therapy, and the *Proteus* and the *Pseudomonas* groups, which are the most difficult to eradicate. The main principles of therapy are, first, to identify the organism and treat with appropriate antibiotic, and, second, to remove any underlying pathologic process in the urinary tract which is producing stasis of urine. High fluid intake still is considered to be a main principle of therapy in this disease. Inexpensive and wide-range medications, such as sulfisoxazole (Gantrisin), sulfamethylthiadiazole (Thiosulfil) and sulfisomidine (Elkosin),[3] are effective against most of the common urinary tract invaders and should be started before the culture has been returned. Mandelamine (methenamine with mandelic acid) is very effective against gram-negative organisms and may be used over a long period of time with practically no side reactions. If the infection does not respond to these drugs, the chloramphenicol (chloromycetin), tetracycline (Achromycin) or nitrofurantoin (Furadantin) should be used. The sensitivity tests performed on the bacteria identified in the urine culture have proved to be very valuable in the choice of the proper antibiotic.

NONSPECIFIC URETHRITIS

Urethritis caused by any organism other than the *Neisseria gonorrhoeae* is termed nonspecific urethritis and is, therefore, a diagnosis of exclusion. The symptoms include urethral discharge, either thick or thin, and burning on urination. This may be a primary disease, or it may be secondary to a gonorrheal infection treated inadequately. This is one of the most difficult conditions to eradicate, and intensive antibiotic therapy should be employed following cultures and sen-

sitivity examination in the laboratory. If intensive and appropriate antibiotic therapy fails, other measures, such as urethral instillation of 5 per cent Argyrol, mild silver nitrate or antibiotic solutions, may be used.

Prostatitis

The prostate gland is subject readily to infection. The infection arrives at the prostate by various routes including (1) retrograde from the urethra, (2) antegrade from the bladder (cystitis) and (3) hematogenous from a focus of infection elsewhere in the body. The patient with prostatitis may complain of a variety of symptoms, but he does not have to have all the symptoms for the diagnosis to be made. These include low back pain, urethral discharge, pain on defecation, difficulty in urination (narrowing of the stream, dysuria, terminal hematuria, burning, hesitancy) or general systemic symptoms (malaise, low grade fever, anorexia) The diagnosis is confirmed on physical examination. By rectal touch the prostate usually is slightly enlarged, boggy and tender. Examination of the prostatic secretion must be done to confirm the diagnosis The presence of white blood cells is indicative of prostatitis. The treatment must include eradication of any focus of infection elsewhere in the body, use of antibiotics according to the culture and the sensitivity tests of the prostatic secretion, abstinence from alcohol, high fluid intake, abstinence from sexual intercourse and weekly prostatic massage until the tone of the gland is felt to be normal.

Venereal Diseases

Gonorrhea

Acute gonorrhea is a specific venereal disease with an incubation period of from 2 to 4 days. The etiology is the *Neisseria gonorrhoeae;* it affects primarily the mucous membrane of the urinary and the genital tracts in both the male and the female. In the male, the diagnosis usually can be made by gram stain of the secretion, although at times culture must be done for confirmation. In the female, on the other hand, the diagnosis usually requires culture. On the stained smear the presence of both extracellular and intracellular gram-negative diplococci is confirmative. It is not too uncommon for two venereal diseases to occur at the same time, notably syphilis and gonorrhea; therefore, it is of prime importance that a serologic test for syphilis be performed before treatment is given for gonorrhea and, monthly, for 4 months following treatment.

Uncomplicated Gonorrhea. Uncomplicated gonorrhea is of acute onset and has had no previous treatment The treatment recommended by the United States Public Health Service is intramuscular injection of 600,000 u. of procaine penicillin G in oil with 2 per cent aluminum monostearate (P.A.M.) or n. n'dibenzylethylenediamine dipenicillin G. (Bicillin) We have been supplementing this in our clinic with a 1-week course of one of the soluble sulfonamides in dosages of 1 Gm. 4 times a day. This regimen results in from 85 to 90 per cent of cures without further treatment

Complicated Gonorrhea. Gonorrheal infection is considered to be complicated when other sites outside the urethra are affected by the disease process. These include gonorrheal epididymitis, prostatitis, seminal vesiculitis and affections of other organs of the body, such as the eye and

the joints. In these diseases, the United States Public Health Service recommends aqueous penicillin G, from 600,000 to 1,200,000 u. per day in divided doses at 2- to 4-hour intervals or equivalent amounts of repository penicillin until signs and symptoms have subsided.

Resistant Gonorrhea. Both complicated and uncomplicated forms of gonorrhea may result in resistant disease. The diagnosis is made on failure to respond to the usual treatment described above. In this group more intensive antibiotic therapy is necessary; very often a combination of two or more of the drugs is used. If secretions are present, culture may prove to be very valuable because the *Neisseria* organisms may have disappeared and secondary invaders may be the cause of the persistent symptoms. In these cases, bacterial cultures and sensitivity studies are valuable in choosing the proper drug.

Prophylaxis of Gonorrhea. Prevention of acute gonorrhea has been effective with the use of 250,000 u. oral penicillin. One tablet is given at least 1 hour before exposure and protects for about 12 hours. This may be repeated as necessary on subsequent days.

Syphilis

Clinically, the diagnosis of primary syphilis should be suspected with any ulcerative lesion on the shaft of the penis. Other ulcerations in the differential diagnosis include traumatic ulcer, chancroid (soft chancre), herpes progenitalis and carcinoma of the penis. The diagnosis is made by darkfield examination and serologic tests. The recommended therapy for primary syphilis by the United States Public Health Service is P.A.M. (penicillin aluminum monostearate 1,800,000 u.), first injection 2,400,000 u., second and third injections 1,200,000 u. each, given at 2- to 4-day intervals, or n, n'dibenzylethylenediamine dipenicillin G (Bicillin) 2,400,000 u. in a single injection.

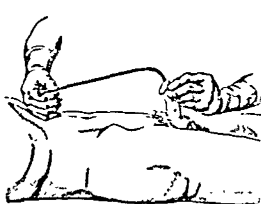
Obstructions

Prostatic

Prostatic obstruction is due to either benign hypertrophy or carcinoma. A patient with symptoms of prostatism and a residual urine of over 100 cc. should be considered for surgical correction and not treated as an outpatient. Prostatic massage, which has been much overused in this disease, is ineffectual and should be reserved for cases of prostatitis. Carcinoma of the prostate should be suspected when there are areas of hardness, when the gland is fixed or when a nodule is palpated. The diagnosis is made by (1) the typical rectal touch, (2) an elevated acid phosphatase, (3) evidence of metastases elsewhere in the body and (4) positive biopsy. It must be remembered that a normal acid phosphatase does not rule out the diagnosis of carcinoma. An elevation of the acid phosphatase is pathognomonic of carcinoma of the prostate, the only exception being recent prostatic massage, which has been shown to cause a transient increase.

Urethral Stricture

As mentioned above, urethral stricture usually is gonorrheal or traumatic in origin. As a rule, this condition is managed best on an outpatient basis with periodic gradual dilatation of the urethra. It is important not only to diagnose the presence of a stricture but also to determine its lo-



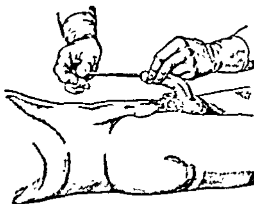
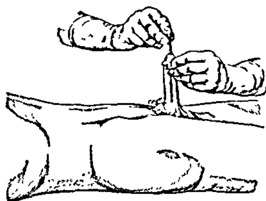


FIG. 324 (*Left*). Holding the penis steady with the left hand, the tip of the sound is inserted into the meatus with the right hand.

FIG. 325 (*Right*). The sound is advanced into the urethra as the penis is drawn up over the instrument.



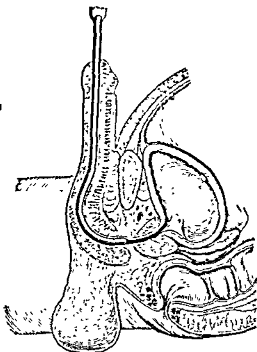


FIG. 326 (*Left*). Resistance is encountered by the sound at the bulbomembranous junction.

FIG. 327 (*Right*). Sagittal section showing the tip of the sound at the bulbomembranous junction (anterior layer of triangular ligament).

cation, size and extent. Extensive involvement may require hospitalization for internal or external urethrotomy. Narrow but passable strictures are amenable to graduated dilatation with filiforms and followers, while metal sounds or woven bougies are reserved for the larger caliber forms.

Urethral Instrumentation

Filiforms and followers are the safest instruments to use when first approaching the problem. After the passage of a filiform, the largest follower that may be passed easily should be inserted. It may be necessary to resort to the multiple filiform technic de-

scribed previously. At weekly intervals the size of the follower is increased gradually until it is possible to pass a metal sound without trauma. This should be done until sounds in the range of a No. 26 to a No. 30 French are inserted easily. At this time the patient is warned to report back at least twice a year for further dilatation.

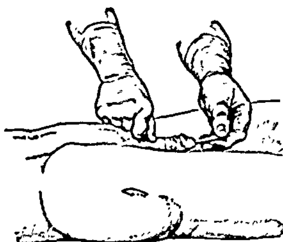


FIG. 328 The handle of the sound is depressed slowly by the left hand. In this way, the tip of the sound follows easily the curve of the posterior urethra The right hand makes pressure downward over the root of the penis to relax the suspensory ligament.

Metal Sounds

The program for the use of metal sounds is the same as for other urethral diators. Periodic dilatation with progressively larger instruments is the proper technic, never more than two sounds being used at each treatment. (Fig. 321-329.) Some urologists prefer the use of woven bougies in place of metal sounds. The technic is the same. It has been our rule with all urethral dilatation or manipulation that the patient be given maintenance

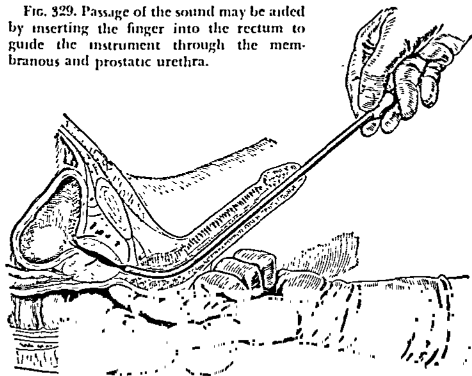


FIG. 329. Passage of the sound may be aided by inserting the finger into the rectum to guide the instrument through the membranous and prostatic urethra.

doses of soluble sulfonamides while under treatment.

SPECIFIC DISEASES OF THE PENIS

Most specific diseases of the penis are beyond the scope of outpatient therapy. The entities that are amenable to treatment are papillomas and Peyronie's disease.

Papillomas

Papillomas are moist wartlike growths on the skin of the external genitals. They are known also as condyloma acuminata, or venereal warts, and should be distinguished from condyloma lata of syphilitic origin. The most common site is the sulcus, or the posterior edge of the glans penis. Treatment consists of electrofulguration, excision or local applications of podophyllin. If there is phimosis or even a redundant prepuce, circumcision must be done to prevent recurrence. The podophyllin treatment consists of the use of 15 per cent podophyllin in tincture of benzoin. Care must be taken in applying this solution not to touch any of the surrounding normal skin. More than one application may be necessary.

Peyronie's Disease

This disease has many synonyms, such as fibrous plaques of the penis, fibrous cavernositis and plastic induration of the corpora cavernosa. There is a history of painful erection; there are fibrous plaques along the shaft of the penis, and often it may be noted that upon erection the penis will curve to one side. A large majority of patients show some response to vitamin E therapy. The dose is 100 mg. alpha-tocopherol 4 times a day for from 2 to 4 months. Bodner, Howard and Kaplan[2] have reported good results from cortisone. Their technic consists of using a 10 cc. Luer-Lok syringe with a 21- or a 22-gauge needle to inject the medication into the plaque. G. H. Teasley[3] uses a solution of 25 mg. of cortisone acetate (Cortone) dissolved in normal saline containing 25 per cent procaine crystals. The forefinger and the thumb of the left hand grasp the plaque and the needle then is inserted into the middle of the lesion. Initially, much pressure is required to inject the solution After 2 or 3 treatments less pressure is needed. Generally, other treatments such as x-ray therapy, radium therapy and surgical incision of the fibrous plaque have been unsuccessful.

Phimosis and Paraphimosis

The emergency treatment for these 2 entities has been discussed above. The final treatment is circumcision.

Circumcision

Circumcision is indicated for (1) congenital phimosis; (2) adherent prepuce; (3) redundant prepuce that interferes with urination and allows smegma and other irritating secretions to collect; (4) recurrent attacks of balanoposthitis, and (5) paraphimosis Any active infection, such as acute gonorrhea, chancroids or acute balanoposthitis, contraindicates circumcision. A dorsal slit should be performed if relief from an inflammatory phimosis is necessary and cannot be obtained by local applications and irrigations.

As a rule, no anesthesia is necessary in the newborn. A general anesthetic is preferable for children. For adults, ordinary infiltration anesthesia is sufficient, procaine 1 per cent being used. Before introducing the needle for the

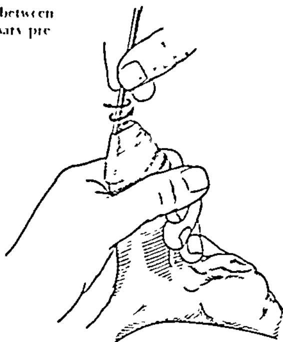


FIG. 330 Method of separating adhesions between the prepuce and the glans This is a necessary preliminary step to circumcision

infiltration anesthesia, the skin surface should be cleansed and sterilized, green soap and 70 per cent alcohol being used. An encircling injection is carried out at the base of the penis, approximately 5 cc. of procaine solution being used. Usually, this can be made with a single skin insertion of the needle, provided a 2 in. needle is used. After the injection is carried round one side, the needle is withdrawn until its point is just beneath the skin Then it is passed round the uninjected side, and the circle of injection is completed. Injection directly

FIG. 331. Technic of circumcision.

doses of soluble sulfonamides while under treatment.

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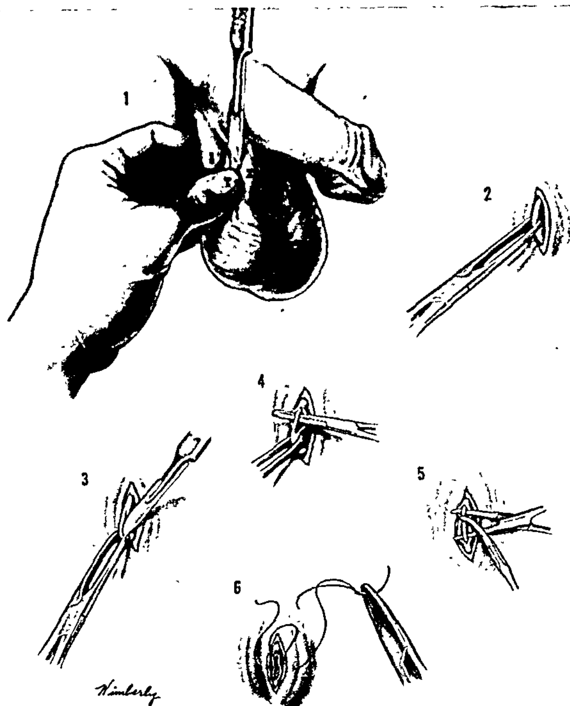


Fig 333. Steps in the technic of vasectomy. See text.

VARICOCELE

Varicocele results from dilatation and tortuosity of the veins of the spermatic cord within the scrotum. In most cases, it is found on the left side and results from poor venous drainage of the left spermatic vein which enters the left renal vein at right

into the corpora cavernosa usually is not necessary. Then the prepuce is retracted and a ring of anesthesia is made under the mucous membrane, immediately behind the corona. To complete the anesthesia, a few drops of solution are injected directly into the frenum. About 2 cc. of solution should suffice for the postcoronal and the frenal injection.

Success of the operation depends on removing more skin than mucosa. In congenital phimosis, adhesions of various degrees frequently are encountered. In infants and children, these often can be broken up with a grooved director (Fig. 330). In adults, it is sometimes more difficult to accomplish this, but all adhesions must be separated if a successful operation is to be performed.

Dorsal Slit and Circumcision (Fig. 331). The tip of the prepuce is grasped with 2 Allis clamps, and a grooved director is inserted between the prepuce and the glans penis. A dorsal slit is made with a pair of sharp scissors to a point about 1 cm. from the coronary sulcus. Then, posteriorly, the frenum and the accompanying prepuce are incised. The prepuce is excised, leaving a small V-shaped section on the posterior surface. Clamps then are applied to any bleeding vessels and these are ligated. Bleeding from the frenular artery particularly should be controlled. The edges of the wound are approximated very completely with interrupted sutures of plain catgut, care being taken to reconstruct the frenum.

At the conclusion of the operation, a sterile dressing of petrolatum gauze is placed about the shaft of the penis. Healing should be complete in 6 or 7 days.

DISEASES OF THE SCROTUM

Most diseases of the scrotum, as in the case of diseases of the penis, are amenable only to hospital treatment. These should be distinguished from those which can be handled on an outpatient basis.

Hydrocele

Hydrocele is the presence of an abnormal amount of fluid within the *tunica vaginalis*. The condition is either congenital or postinflammatory. Usually, the cystic mass can be made out by palpation, and transillumination will confirm its fluid contents. Although surgical excision is perhaps the treatment of choice, aspiration of the hydrocele often yields good results, especially if the hydrocele is small. (Fig. 332.)

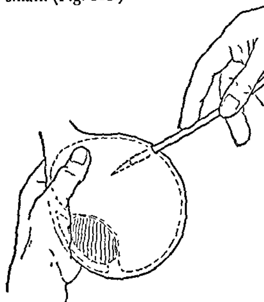


Fig. 332. Method of tapping a hydrocele. A trocar is inserted at the junction of upper and middle surface of the hydrocele, while pressure with the left hand keeps the hydrocele tense.

22

Arm and Shoulder

BENIGN TUMORS

The forearm and, more especially, the upper arm are not unusual sites of benign tumors. These vary from simple skin blemishes, such as pigmented moles, which usually are hairy and often occur round the forearm and the elbow, to large lipomas and fibromas (Fig. 334).

Treatment. Most of these tumors may be removed easily under local anesthesia through an elliptical incision. Primary suture of the wound and a pressure bandage of elastic adhesive are sufficient to give an excellent result. As a rule, splinting is not necessary following these operations because adequate pressure and immobilization can be obtained by the bandage.

In the removal of larger skin defects, such as pigmented hairy moles and scars or tattoo marks, the method employed by Davis is of value. In such cases, instead of removing the entire lesion in one step, an elliptical excision is made from the center of the lesion, and the edges are approximated. After healing occurs and the stretching of the approximated skin is permitted, a second similar operation is performed, the scar previously made and another elliptical portion of the remaining blemish being ex-



Fig. 334. Fibro-osteomyxoma. This lesion was removed under local anesthesia in an ambulatory patient.



Fig. 335 Multiple fibrolipomas in symmetrical distribution over the forearms

angles. Treatment consists usually of scrotal support, and most cases are self-limited. If pain occurs and persists, surgical excision is advisable.

Testicular Tumors

Tumors are mentioned to point out that any nontransilluminating mass in the scrotum requires hospitalization for definitive diagnosis and treatment. If tumor is suspected, not only is attempted aspiration contraindicated but it may be dangerous by causing local spread of the disease.

Vasectomy

Commonly, bilateral vasectomy is employed preliminary to prostatectomy as a prophylactic measure to prevent epididymitis. It is performed also to sterilize the male. (Fig. 333.)

Technic

The vas deferens is rolled between the fingers, separated from the rest of the spermatic cord and held just underneath the skin of the scrotum. Then a 1 per cent procaine solution is injected into the overlying skin. Two towel clips are placed about 2 in. apart to hold the skin and the vas away from the rest of the cord. With the vas thus immobilized, it is easy to make a small incision through the overlying skin, exposing the vas deferens and separating it from its sheath. After the towel clips are released, the vas can be pulled out 2 or 3 in. About ½ in. is resected, and the ends are ligated. Then the ends of the vas are placed lateral to each other so as to overlap. In this position they are tied to each other by ligature, thus precluding any possibility of reuniting.

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measure of importance is the administration of appropriate antibiotic therapy. Since lymphangitis is caused almost always by a streptococcus, and occasionally by a staphylococcus, penicillin usually is effective. There is no open wound; therefore, cultures and sensitivity tests cannot be carried out. Erythromycin and the broad-spectrum antibiotics also would be expected to be effective in most cases. If these drugs are used early enough, suppuration usually can be avoided, but if they are used late and abscess formation has occurred, incision and drainage are necessary.

LESIONS OF THE OLECRANON BURSA

Olecranon Bursitis (Miner's Elbow)

Etiology. The olecranon bursa overlies the olecranon and is one of the subcutaneous bursae most frequently involved (Fig. 129). It develops between the skin and the bony prominence of the olecranon in response to friction. If friction and trauma continue for a long time, a chronic inflammatory change takes place in the bursa, with the result that it becomes thickened and rubbery. Trauma may result in a secretion of fluid in the bursa with a tense swelling under the skin over the point of the elbow. If acute trauma has occurred, there is definite tenderness, and the swelling may be painful, whereas usually in the chronic cases it is painless.

Treatment. In younger persons, it is possible often to aspirate the bursa and apply a firm elastic-pressure dressing and an elbow splint. Usually, a rubber sponge applied with a firm bandage is adequate. In such cases, formation of the effusion may not recur, but, if it does, it will recur in slight amounts only.

In older individuals, when the bursa has thickened definitely, the swelling usually is not painful, and on palpation small hard movable bodies within the bursa may be noted. These often are mistaken for chips of bone, especially if there is a history of previous injury, but really they are fibrous villi or straps that extend across the bursa. Pressure upon these fibrous projections gives acute pain.

In chronic olecranon bursitis, subcutaneous incision of the bursal walls under local anesthesia has proven to be very successful (see p. 213). By separating the roof from the floor of the bursa, there no longer is a cavity to collect fluid. The bursa is obliterated completely, and it disappears. This is an office procedure, and it avoids a formal operation.

In some cases of olecranon bursitis of the chronic type, excision of the bursa is carried out. The operation may be performed easily under local anesthesia. The patient lies on the table with the arm across the chest (Fig 133). An elliptical incision is so made that the scar does not lie over the tip of the elbow. The bursa is found to be a tense structure that is separated easily from the overlying skin but is densely adherent to the fibrous tissue over the olecranon. On opening the bursa, a yellowish fluid escapes, and usually the fibrous villi and the straps that extend into the lumen of the bursal cavity may be seen Care must be taken to obtain good hemostasis, after which the skin flap is sutured in place, and a pressure dressing is applied. When hemostasis is not absolute, it is wise to insert a small rubber-tissue drain for 24 hours. Usually, an internal right-angled splint is used for 2 or 3 days. Skin sutures are removed at the end of a week or 10 days, at which time

cised. Two or three operations are necessary for complete removal of the lesion. In the end, a single linear scar is left, and a considerable area of the skin may be removed without the necessity of grafting. However, it is quite possible in many such cases to excise the entire skin area and apply a primary skin graft. These operations may be performed easily under local anesthesia in the ambulatory patient. The only precaution necessary is that splints should be applied. In this way, pressure dressings are maintained more easily, and primary healing is more certain.

MULTIPLE FIBROLIPOMAS

These are common tumors of the forearm and the upper arm. They are small lesions in the subcutaneous fat; usually they are symmetrical, occurring in both forearms or upper arms (Fig. 335). They cause no discomfort unless they are traumatized; then they become painful. Frequently, however, they are removed for cosmetic reasons.

Treatment. Under local anesthesia, the tumors are shelled out without much difficulty, and the skin edges are approximated with interrupted sutures. The prognosis should be guarded, as further fibromas may appear in the extremities involved.

EXCESS SKIN AFTER LOSS OF WEIGHT

Occasionally, in patients who have lost much weight, an excess of skin is left, especially in the upper arm. This may cause the patient considerable annoyance. It may be removed easily under local anesthesia, an elliptical area of skin being excised and a primary suture being performed. In this case, as in the removal of tumors, an elastic adhesive pressure bandage is applied.

ACUTE LYMPHANGITIS

Etiology. Generally, acute lymphangitis of the upper extremity arises from a primary finger infection, which may be the result of a minor traumatic injury, such as a wound, a scratch or even the prick of a pin. Occasionally, the patient may not have any recollection of an injury, and none may be discovered on examination. The infection may begin on either the dorsal or the palmar side of the finger; the usual infecting organism is the streptococcus.

Symptoms. Frequently, the systemic symptoms at first are more marked than the local ones, so that the patient may experience a chilly sensation or malaise before his attention is directed to a dull pain and swelling in the finger involved. However, within a few hours, red streaks may appear extending from the finger across the dorsum of the hand and up the forearm. These streaks, outlining the course of the subcutaneous lymphatics, lead to the regional lymph nodes. Those from the little and the ring fingers extend to the epitrochlear nodes, and those from the middle and the index fingers and the thumb to the axillary nodes. Those from the middle finger may extend also to the supraclavicular nodes.

These infections are dangerous because of the possibility of extension to the blood stream. However, the majority of them will subside in a relatively short time with appropriate therapy.

Treatment. Splinting is the most important of all local therapeutic measures. The finger involved and the entire arm must be placed at absolute rest. The internal right-angled splint that extends to the ends of the fingers is best for this purpose. The second

Any lesion of the structures that form the floor or the roof of the bursa may cause a disturbance of motion associated with pain. These lesions fall into two main groups, those that are traumatic and post-traumatic and those that are nontraumatic and degenerative.

Traumatic and Post-traumatic Lesions

Acute Traumatic Subacromial Bursitis

Etiology. Whenever a thrust is made by the hand or the forearm, the force is transmitted to the area of the subacromial bursa. The coraco-acromial arch prevents upward dislocation of the head of the humerus, so that a fall on the hand or the forearm may cause contusion of the bursal surfaces with slight, or even severe, bursitis. Injury to the bursa occurs also in all dislocations at the shoulder and in fractures of the upper humerus. This fact often is overlooked in dealing with the more evident bony lesions, but it is a factor in the disability produced by these injuries. In young individuals, the bursitis results in little or no final disability, but in the elderly, if the bursal lesion is neglected, it may cause persistent trouble.

Acute traumatic bursitis with severe pain also may follow a fall in which the point of the shoulder impinges forcibly on a hard object, or it may be secondary to a tear of the supraspinatus tendon or a fracture of the greater tuberosity, both of which underlie the floor of the bursa

Diagnosis. The patient complains of severe shoulder pain and declines to move the arm, holding it rigidly at the side. Even passive motion causes severe pain. The arm may be elevated passively through 30° to 60°, but close inspection reveals this motion to occur by rotation of the scapula on the chest rather than at the scapulohumeral joint. Reflex muscle rigidity in acute bursitis may be so great that abduction is almost impossible, simulating partial or complete tear of the supraspinatus tendon. Palpable swelling and



Fig. 338. Adhesive strapping of the shoulder. Straps are applied to the arm and held in place by an assistant while pressure is made upward across the shoulder. Alternate layers are applied front and back until the entire shoulder area is covered. The ends of the adhesive on the arm are anchored with a circular turn of elastic adhesive bandage. The ends over the chest and the back are anchored with 2 or 3 transverse adhesive strips. The purpose of the strapping is to lift up the arm. (Ferguson, L. Kraeer Ann. Surg 105: 243)



FIG. 336 Chronic granulating wound at the site of an incised suppurative olecranon bursitis. Excision of the granulating area permitted rapid healing.

normal function is resumed almost at once.

The treatment of chronic olecranon bursitis by the injection of sclerosing solutions has not proven to be too successful in our hands. Other bursae, such as the prepatellar, frequently respond very well to injection, but usually the olecranon bursa continues to secrete fluid, and the swelling does not subside.

SUPPURATIVE OLECRANON BURSITIS

Occasionally, the olecranon bursa becomes the site of a secondary infection following a furunculosis over the tip of the elbow. In such cases, the bursa becomes distended and tender.

Treatment. Conservative therapy, consisting of antibiotics, hot wet dressings and splinting, may be tried; however, as a rule, incision and drainage of the bursa are necessary. Following simple incision, the bursa usually is obliterated, and the wound heals There may be a few cases in which healing will be incomplete because of the large amount of chronic fibrous tissue in the bursa wall. At the base of the wound, there is a chronic granulating area that refuses to heal, and excision of this area is necessary to obtain rapid healing (Fig. 336).

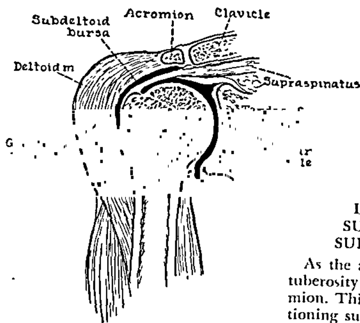


FIG. 337. Diagrammatic cross section of the shoulder area showing the relation of the subacromial bursa to the deltoid muscle, the greater tuberosity, the supraspinatus tendon and the acromion.

LESIONS OF THE SUBACROMIAL, OR SUBDELTOID, BURSA

As the arm is elevated, the greater tuberosity slides beneath the acromion. This requires a smoothly functioning subacromial bursa (Fig. 337)

bursitis as well as the acute bursitis associated with dislocations, fractures and tendon injuries. It is due to neglect of early motion of the shoulder.

In addition, any injury to the shoulder, even without bursal injury, that causes pain on motion and keeps the arm at the side without exercise for a few weeks may be complicated by bursal adhesions. This is particularly likely to occur in elderly patients who have had prior attritional changes, that is, a fraying out of the short rotator and the biceps tendons.

Diagnosis. After a few weeks, the clinical picture of bursitis with adhesions may be superimposed on the picture of the acute lesions described above. It is obvious that accurate diagnosis becomes extremely difficult. The well-advanced clinical picture of posttraumatic bursitis with adhesions is typical. The pain of injury subsides after a week or two and is replaced by ill-defined pain over the shoulder that radiates to the insertion of the deltoid, to the elbow or to the wrist and the fingers and becomes progressively more severe.

Usually, examination discloses atrophy of the spinatus, the deltoid and the arm muscles, often associated with vasospastic phenomena such as coldness and stiffness of the hand and a glossy, atrophic skin. The bursal area is quite tender. Active elevation of the arm is limited strikingly and is painful. If the scapula is prevented from rotating, the patient may be able to abduct the arm only from 10° to 30°. This is the characteristic physical sign of this condition. Internal and external rotation also become restricted greatly.

Treatment. Treatment is directed toward separating the adhesions and restoring normal motion. Until this is accomplished, no permanent relief of pain is to be expected.



Fig. 340. Wall-climbing exercise. The patient creeps up a vertical wall with his fingers, thus stretching the bursal adhesions by elevating the arm (Ferguson, L. Kraeer: Ann. Surg. 105:213)

When the symptoms are mild and motion is restricted only moderately, stooping exercises (Fig. 339) and wall-climbing exercises (Fig. 340) are prescribed for 10 minutes, 3 to 5 times daily, and are followed by a brisk rub with methyl salicylate ointment. The patient is advised to use the arm as much as possible and to sleep with the arm above the head. Salicylates and barbiturates should be given in large doses at first.

If improvement is not marked and continued with this form of conservative therapy, cortisone may be given.

fluctuation may be present, but always there is acute diffuse tenderness just below, and anterior to, the acromion.

The diagnosis of simple acute traumatic subacromial bursitis may be made only when dislocations and fractures of the head of the humerus and tears of the short rotator tendons have been excluded, since injuries to these structures may be manifested by an acute bursitis if by no other signs. The procaine injection described below may aid in the diagnosis.

Treatment. Injury to the bursal surfaces is important because of its sequelae. If the arm is held at the side for a sufficient length of time, dense adhesions form between the opposed surfaces and limit humeroscapular motion. During the first 24 to 48 hours after injury, treatment is aimed at relieving the pain and at obtaining rapid subsidence of the acute reaction to trauma. If fluctuation is present, the bursa is aspirated, and from 5 to 10 cc. of 1 per cent procaine is injected. Immediate relief of pain and spasm follows, and the diagnosis of laceration of the short rotator tendons may be made if elevation of the arm cannot be initiated or is very weak. The shoulder is immobilized in partial abduction with a thick axillary pad, and a sling and a swathe to relieve the tension of the shoulder muscles are applied. If adhesions form, these will separate when the arm is brought to the side later. An adhesive or an elastic adhesive strapping (Fig 338) over the shoulder is of some benefit. Ice bags are advised during the first 24 to 48 hours, and sedatives are given if necessary.

After 3 to 5 days, when the acute symptoms have subsided, stooping exercises (Fig. 339) are begun to avoid adhesions and stiffness. They should be performed for from 2 to 5 minutes 4 times daily. Heat and gentle massage twice daily are helpful at this time. Recovery often is complete in from 7 to 14 days.

Post-traumatic Adhesions in the Subacromial Bursa

Etiology. It has been indicated that this condition may follow simple acute

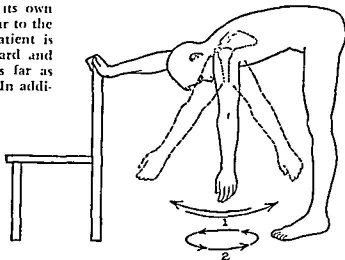


Fig. 339. Stooping exercises for shoulder lesions (after Codman). The patient bends forward, grasping a chair with the hand of the sound arm; the painful arm falls forward of its own weight to become perpendicular to the floor. In this position, the patient is asked to swing the arm forward and backward gently, raising it as far as possible up toward the head. In addition, circular motions should be performed, carrying the arm in an arc forward and backward Often it is advisable to have the patient hold something in his hand during this exercise. The old-fashioned flatiron is a good substitute for a dumbbell for this purpose.



FIG. 341. Roentgenograms of 2 patients showing large deposits of calcified material over the greater tuberosity. Both patients were operated upon under local anesthesia, and the calcified deposits were drained by incision. (Ferguson, L. Kraeer. Ann. Surg. 105:213)

no roughening of the floor of the bursa, it may cause no symptoms whatever. Most often these deposits are chalky hard and are found to lie above the head of the humerus in the roentgen film.

Symptoms and Findings. The calcareous deposits may cause acute or mild symptoms, or they may not cause any symptoms whatever. Roentgen films taken with the arm in internal and external rotation help to locate the site and the type of calcium deposit.

Acute Form. Following insignificant trauma or without obvious cause, the patient begins to have pain in the shoulder that is localized over the bulge of the deltoid and occasionally radiates down the arm. The pain grows worse rapidly, and in a few days it may be agonizing. Motion at the shoulder intensifies the pain, and this forces the patient to hold the arm rigid at the side. On examination, there may be visible swelling over the subacromial bursa. Intense spasm of the muscles of the shoulder prevents passive motion, and the intense pain permits little or no active motion. On palpation, acute agonizing tenderness is found over the greater tuberosity when the calcification is in the supraspinatus tendon, or a little in front of, or behind, the tuberosity when the other tendons are involved. When the history of some injury has been given, it is important for the purpose of differential diagnosis to establish the violence and the character of the injury. In most cases, it will become apparent that the injury to which the condition is attributed has not been violent enough to cause laceration of the short rotator tendons or fracture of the greater tuberosity, the two conditions which may simulate acute calcareous tendinitis most closely.

Mild Form. The patient becomes aware of some vague discomfort in the shoulder that becomes more annoying after several weeks. Usually, the pain is localized over the deltoid, and it may radiate down the arm. It is apt to be brought on by full elevation of the arm. In these cases, the cal-

Usually, 3 oral doses of 25 mg. each are given daily for a week at least. As a rule, decreased pain and increased motion in the shoulder become apparent in from 2 to 3 days. Depending on the improvement noted, cortisone may be continued in the above dosage or reduced to 50 mg. daily in 3 or 4 divided doses. Exercises and salicylates, as above, should be continued. Cortisone gradually is reduced and stopped when the pain has disappeared and shoulder motion has returned to normal.

Local injections of hydrocortisone acetate (Compound F acetate) also have been used in the treatment of the posttraumatic form of bursitis. The results are less dramatic than those obtained in acute bursitis. Usually, from 25 to 50 mg. of hydrocortisone is injected after the area has been infiltrated with 1 per cent procaine. The injection may be repeated in from 3 to 5 days.

Nontraumatic and Degenerative Lesions

Calcareous Tendinitis of the Short Rotator Muscles

Calcareous deposits form frequently in the supraspinatus tendon close to the greater tuberosity. Less frequently, such deposits may be found in the subscapularis and the infraspinatus tendons. While calcareous tendinitis occurs most commonly about the shoulder, the tendinous insertions about hip, wrist, knee, ankle, elbow and finger joints may be affected.

Etiology. The cause of this condition is not known, but it appears to be due to some local disturbance, possibly of the blood supply, rather than to any toxic or infectious cause. There may be some relationship between this condition and the calcification seen in ischemic or necrotic areas.

Pathology. When a patient with an acutely painful shoulder due to calcification is operated upon and the floor of the subacromial bursa is exposed, a small ring of hyperemia indicates the site of the calcification. When an incision is made into this area, a soft, pasty, yellowish-white mass is extruded. Often it has the consistency of tooth paste and appears to have been held in the area under considerable tension. When the symptoms have been less acute and such an area is exposed, the calcareous material is seen as dense, gritty masses or plaques. When the soft calcareous material is examined under the microscope, it is found to consist of a mass of round and ovoid bodies, ranging in size from that of bacteria to masses 10 to 15 times the size of white blood cells. The bodies are whitish and translucent, and they appear to be elastic. Their composition varies, but most often they are mixtures of calcium phosphate, calcium oxalate and organic matter.

In the acute forms of the condition, the symptoms appear to be due to an increase in local tension about the area of calcification, possibly because of an inflammatory reaction excited by the calcareous material. Usually, the area of calcification is large and soft, and it lies well out over the greater tuberosity (Fig. 311). To relieve the tension relieves the symptoms.

In the milder forms, the symptoms are due to the mechanical effect of the calcareous material. When the calcification is present in the supraspinatus tendon and causes some roughening of the floor of the subacromial bursa, there is an irregularity in the rhythm of elevation accompanied by discomfort. When the deposit lies in the substance of the tendon so that it causes

Asymptomatic Form. Occasionally, in a patient who has symptoms in one shoulder, roentgenograms are made of both shoulders for comparison, and calcareous deposits are seen in both, although only one is painful (See Fig 312). This brings out two points: first, that the simple presence of a calcareous deposit does not in itself cause symptoms and, second, that the symptoms are due either to inflammatory reaction about the deposit or to some mechanical interference with shoulder motion at the subacromial bursa.

Treatment. In the acute form, the symptoms often are so severe that relief is required urgently. Several methods of therapy may be used. In the belief that the acute pain is due to an inflammatory reaction round calcium deposit in the supraspinatus tendon, it is logical to assume that

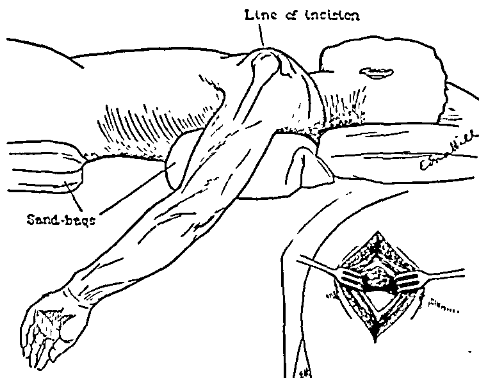
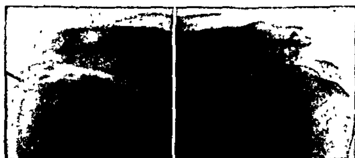


Fig. 313 Position of the patient on the operating table for incision of the subdeltoid bursa and drainage of the calcified deposit in the supraspinatus tendon. Note that the arm is in internal rotation. The incision extends downward and anteriorly from just below the acromioclavicular junction for a distance of about 1 or 2 in.

(*Inset*) Incision of the subdeltoid bursa. After cutting through the skin and the subcutaneous fatty tissues, the deltoid fibers are separated. Blunt dissection is employed to divide the roof of the bursa, to expose the head of the humerus and the floor of the bursa. In the case illustrated, the bursa contained coagulated lymph as well as an area of calcification in the supraspinatus tendon. The latter was drained by a simple incision The patient experienced almost immediate relief of the agonizing pain and, within 2 weeks, was able to resume almost normal function of the arm. She was treated as an ambulatory patient throughout.

careous deposit lies just beneath the floor of the bursa and impinges against the edge of the acromion when the arm is abducted. As a rule, the symptoms do not vary much for the better or the worse if the patient is watched for a few weeks, although ultimately, if the arm is used constantly, the symptoms will disappear. Failure to use the arm may result in adhesions between the bursal surfaces; the result may be, in addition to mild calcareous tendinitis, disturbances incidental to bursal adhesions.

In the uncomplicated form, on examination there usually is little visible or palpable change in the shoulder. A tender spot may be found proximal to the greater tuberosity. The patient can lift the arm through its full range, but he has some difficulty in doing so and shows a disturbed rhythm of elevation accompanied by pain.



A





B C D

FIG. 342. Roentgenogram of right shoulder with needle in center of the deposit before infiltration therapy. Note the presence of a deposit also over the left shoulder (A), which was completely symptom free at that time (B) [illegible] Note frag- [illegible] beginning [illegible] infiltration [illegible]) Roent- [illegible] complete disappearance of the deposit on the right side. Roentgenogram of the left shoulder taken at the same time showed the same findings as in A (*right*). (Lapidus, P. W.: Infiltration therapy of acute tendinitis with calcification, Surg., Gynec. & Obst. 76:715)



FIG. 311. Large area of calcification with spontaneous rupture into the bursa, the patient had spontaneous relief of the agonizing pain from which he had been suffering. The calcified material that had escaped into the bursal sac may be seen outlining the lower portion of the sac over the greater tuberosity.

other forms of treatment tried. It has been the author's experience that at times roentgen therapy gives surprising relief of pain in acute "bursitis" after a single treatment, but that less dramatic results are obtained in the subacute types of bursitis.

The most recent and often successful method of treatment of acute subdeltoid bursitis is by the local injection of hydrocortisone (Compound F).[4] It is not quite known exactly how this acts, but it is presumed to bring about a decrease in inflammation in the calcareous area. The injection of hydrocortisone gives the best results when there is a localized area of pain and tenderness. The injection is made into this area, but there is probably some "spreading" of the effect.

The injection may be carried out as an office procedure. A search with the examining finger easily identifies the most tender area, and the skin over this area is marked with a pencil. After skin preparation with alcohol, the skin, the subcutaneous tissues and the muscle are infiltrated with 1 per cent procaine. Then, with a syringe and an 18-gauge needle, hydrocortisone ½ to 1 cc. (12.5-25 mg.) is injected into the painful area. The needle should be advanced slowly until it impinges upon a firm structure (supraspinatus tendon), then withdrawn slightly and the injection made.

The results of hydrocortisone injections in the acute type of bursitis have been dramatic.[7] Usually, there is an increase in pain or soreness during the first 24 hours after injection, and thereafter complete relief of pain and resumption of normal function. The patient should be provided with sedation for use during the first day and night after the injection. If complete relief of pain has not been obtained, the injection may be repeated in amounts up to 2 cc. in from 3 to 5 days. Coventry[4] has used this method of treatment for more than a year and believes that hydrocortisone injections offer "as much relief as any method formerly used and probably more."

In the mild form, in which symptoms consist mainly of some discomfort during shoulder motion, no radical form of treatment is indicated. Procaine injection is of benefit, but operation seldom gives any considerable relief. Roetgen therapy may be tried. Hydrocortisone injections give

relief of tissue tension will cause relief of pain. This may be accomplished by needling or incising the calcareous deposit. If needling is to be tried, a skin wheal is made with procaine over the point of maximum tenderness. The subcutaneous tissues are infiltrated, and a large-bore 16 to 18 gauge needle is directed into the calcified area. The area is infiltrated with from 5 to 10 cc. of 1 per cent procaine solution. Without withdrawing the needle from the skin, several punctures of the calcified area are made, and each time a small amount of procaine solution is injected. Even better than this is the introduction of a second needle into the calcified area. One per cent procaine solution is injected through the first needle, and very often it can be seen running out of the second needle, carrying flakes of calcareous material with it. The calcareous material does not need to be removed completely. In most instances, it is sufficient to remove enough to relieve tension in the calcareous deposit and to allow the rest to disperse into the tissues, from which it is absorbed rapidly (Fig. 312). If the calcified area has been punctured and some of the calcareous material escapes into the bursa or is aspirated through the needle, almost immediate relief of pain is obtained. The residual soreness due to the trauma of the needling can be relieved by appropriate sedation for 1 or 2 days.

If, however, the needle cannot be entered into the calcareous area and if the symptoms are very severe, dramatic relief may be obtained by operation. Under local anesthesia, an incision is made downward from the anterior margin of the acromion process for from 1 to 2 in. The fibers of the deltoid are split, and the roof of the subacromial bursa is picked up with hemostats and incised. With the elbow flexed to a right angle, the arm is rotated very gently by an assistant, and the floor of the bursa is examined. A zone of hyperemia with a central yellowish area will come into view. Often this hyperemia is about 1 cm in diameter. An incision is made into this area in the direction of the fibers of the supraspinatus tendon, and immediately a mass of pasty, yellowish-white material is extruded. The symptoms usually are relieved immediately, and they may disappear entirely within 24 hours. No attempt is made to close the roof of the bursa. The deltoid fibers are approximated by 2 or 3 sutures of plain catgut, and the skin is closed with sutures or clips (Fig. 313). If discomfort is considerable and there is a disinclination to use the arm, a thick axillary pad should be applied to maintain a slight degree of abduction. Active motion should be started as soon as it can be tolerated by the patient. Stooping exercises may be used initially.

In rare instances, the calcareous deposit may rupture spontaneously into the subdeltoid bursa (Fig. 314). When this occurs, almost immediate spontaneous relief of pain and early resumption of normal function occur.

Roentgen therapy[2] may be employed and gives the best results when the symptoms are severe. It may be used also in females who object to having scars about the shoulder and in patients who dread operation. In many instances, there will be considerable relief after 1 or 2 treatments. If there is no relief after treatments on 2 successive days, it is unlikely that further roentgen therapy will be beneficial. This method of treatment should be abandoned and one of the

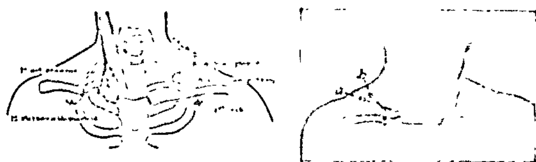


FIG. 313. The drawing of the nerves and the muscles of the neck shows the relation of the anterior scalene to the subclavian artery and the brachial plexus. On the right is shown the difference in position of the needle (a) for injection of the anterior scalene and (b) for brachial plexus block. For scalene injections, the needle is inserted almost transversely into the muscle belly, which is palpable subcutaneously.

dences of bone atrophy in the upper humerus.

In many of these cases Neviaser[13] found the condition to be an adhesive capulitis between the head of the humerus and the capsule of the shoulder joint. Tenderness may be present over the bicipital groove, and this has led Lippmann[8] and DePalma[5] to believe that in many of these cases the condition really is due to a tenosynovitis of the long head of the biceps tendon. In other cases, myalgic trigger points may be found in the muscles of the shoulder girdle. Travell, Rinzler and Herman[19] found these areas most often in the serratus posterior superior and in the infraspinatus. They were identified by pressure to produce pain in the reference zones in the arm, the forearm and the hand These authors were able to relieve the pain and disability by injection of the trigger points with procaine solution.

In our experience, most patients have responded eventually to repeated procaine infiltration along the anterior part of the bursa and the bicipital groove and of any other tender spots that can be demonstrated. This must be coupled with persistent attention to shoulder exercises by the patient. He should be assured that recovery will take place eventually if the prescribed exercises (see p. 161) are carried out faithfully. Low intensity diathermy, hot towels or infrared lamps are types of heat that are helpful. Light stroking massage helps to produce relaxation of tense muscles. Russek[14] believes that muscle spasm is one of the primary factors in the pain mechanisms of the shoulder. If progress is slow, or if it ceases, manipulation under general anesthesia may be performed, followed by exercises and procaine injections as before. This condition often is a test of the patience of both physician and patient, but persistence in treatment usually will be rewarded by a full recovery.

If motion does not increase and pain is not reduced by a week's trial of physicial therapy as described, cortisone may be added. Coventry[4] usually gives 3 oral doses of 25 mg. of cortisone daily. This dosage is continued for a week, or even longer, up to 3 to 4 weeks. If response is good, the dose may be reduced to 50 mg.

results that are less striking than when used for acute bursitis, but they may give partial relief of pain and discomfort. For the majority of cases, it is advisable to have the patient continue active use of the arm, to prescribe heat and massage at home and to assure the patient that the symptoms will subside after a certain length of time.

In the asymptomatic form, no treatment is indicated.

Bursal Lesions Due to Wear

Meyer[10] has shown that after many years of use the shoulder may exhibit evidence of wear. The ordinarily smooth surface of the supraspinatus tendon shows fibrillations and possibly minute tears, and the floor of the subacromial bursa becomes roughened. The tendon of the long head of the biceps may undergo similar changes, and they may be accompanied by mild symptoms. However, if active use of the arm continues, the patients rarely complain of more than occasional slight discomfort or stiffness. If the arm is immobilized for any reason, the roughened bursal surfaces may agglutinate and produce pain on motion. Because of the pain, motion is limited, and the adhesions grow more dense; thus, lesions due to wear are especially important as etiologic factors in subacromial bursitis with adhesions.

Bony Excrescences, Villi and Bands in the Bursa

Symptoms. Chronic bursitis also occurs without adhesions. There is a gradual onset of mild pain at the shoulder; this is brought on by motion and disappears when the arm is at rest. The total range of motion is impaired very little, if at all; motion at the shoulder, however, may exhibit a definite change in rhythm. Examination often discloses nothing but mild tenderness over the subacromial bursa The patient may twist and turn his arm uncomfortably during the process of elevating it, although the total range of motion may be good.

Etiology. Roentgen examination of such shoulders may show no abnormalities, or a tiny bony excrescence may be visible at the lateral margin of the acromion or on the upper surface of the greater tuberosity. When such excrescences are present, the pain occurs usually when the greater tuberosity is about to slide beneath the acromion. When the roentgenogram is negative, the discomfort may be due to thickened folds of bursal lining or to the formation of villi in the bursa. These cause some mechanical irritation of the bursa and interfere to a variable extent with motion.

Treatment. If symptoms are mild and not progressive, no treatment other than gentle home physiotherapy is indicated. On the other hand, if symptoms are progressive and troublesome, it is advisable to perform an exploratory operation on the bursa and remove any bony excresences, villi and bands that may be present.

PERIARTHRITIS OF THE SHOULDER (FROZEN SHOULDER)

Periarthritis of the shoulder is a term loosely applied to shoulder conditions characterized by pain, atrophy and limited mobility of uncertain etiology, and patients often are given this diagnosis by exclusion. The condition usually is seen in the fourth to the sixth decades of life, and often it is associated with radiation of pain to the arm and the fingers. Roentgen examination is negative except for evi-

increasing gradually in severity. The location and the distribution of pain vary. Most commonly, it is over the shoulder and the upper arm, with radiation to the neck or the scapula, or down the arm to the elbow, the wrist or the fingers. In some instances, the pain may be mainly over the shoulder, the scapula and the axilla, in others, it is most severe over the arm and the elbow and radiates down the ulnar side of the forearm and the hand. The character of the pain varies from case to case, and from time to time in a given case. It may be dull, aching and twisting, sharp or burning, or combinations of these types. It increases often with work, such as typing and sweeping, and subsides when the arms are raised and rested. Very often, the pain is much worse at night. Paresthesias may be present.

At first the mobility of the shoulder is not decreased. Later, there is likely to be some limitation of motion due to spasm, disuse and pain. Often this is accompanied by slight muscle atrophy and diffuse tenderness over the painful areas.

Vascular disturbances may be found in some cases; the hand becomes stiff, slightly edematous, glossy, and often cold and dusky. Actual diminution in the amplitude of the radial pulse may be palpable or may be demonstrable by the oscillometer in occasional cases.

Diagnosis. The diagnostic signs are similar to those in cervical ribs: (1) pain in part or all the brachial distribution; (2) absence of a local cause of pain such as a muscular or a bursal lesion, (3) tenderness over the scalenus anticus muscle just behind the lateral edge of the sternocleidomastoid; (4) vascular disturbances; (5) muscle atrophy; and (6) temporary relief of pain by infiltrating the scalenus



FIG. 316. Patient receiving injection of the scalenus anticus. Note position of the needle almost in the lateral plane of the body. The muscle can be identified with the index finger of the left hand while the injection is being given.

anticus muscle with 10 cc. of 1 per cent procaine (Fig. 316). This is a most valuable and constant finding. The absence of signs 3, 4 and 5 does not exclude the diagnosis.

Usually, there is striking partial or complete relief of pain within 5 to 10 minutes if pain was present immediately prior to injection. Often this is accompanied by increased mobility of the arm and the shoulder. In many instances, a Horner's syndrome of drooping eyelid, enophthalmos, constricted pupil, dilated subconjunctival vessels and lacrimation appears on the affected side, indicating anesthesia of the cervical sympathetic fibers. This lasts from 30 to 60 minutes.

It is important to exclude subacromial bursitis with adhesions and calcification in the supraspinatus tendons, since these may *induce a secondary* scalenus syndrome that is relieved temporarily by *injection*. Cervical rib syndrome can be excluded only by roentgen examination, *since it is* also likely to be relieved temporarily

daily in divided doses and gradually reduced or discontinued as the improvement warrants. Coventry believes cortisone to be a most valuable adjunct to the treatment of periarthritis of the shoulder. Our more limited experience does not warrant more than a hopeful outlook from cortisone therapy

One should be aware of the complications that may follow cortisone therapy. Usually, prolonged administration of the drug is not recommended for periarthritis.

SCALENUS ANTICUS SYNDROME

The scalenus anticus muscle has its origin from the transverse processes of the third to the sixth cervical vertebrae. It inserts into the scalene tubercle on the upper surface of the first rib close to the sternum. The subclavian artery and the branchial plexus arch over the first rib just behind this muscle and pass downward to the arm (Fig. 315) Just behind the nerves and the vessel are the other scaleni.

Etiology. The scalenus anticus is a factor in the cervical rib syndrome, since division of the muscle often relieves the symptoms. In many cases a cervical rib syndrome is present; that is, brachial plexus neuritis with or without vascular disturbance. However, no cervical rib is demonstrable. In these cases, spasm or hypertrophy of the scalenus anticus may cause the symptoms by direct pressure on the nerves and the artery. Pressure also may occur indirectly, since the spastic scalenus anticus may elevate the first rib unduly, the elevated rib pressing into the plexus and the artery as they go over it to pass down the arm. Furthermore, a vicious cycle may occur since the scalenus anticus is supplied by branches of the lower 4 cervical nerves that form the brachial plexus. Irritation of the plexus causes further scalenus spasm and higher elevation of the first rib. As in cervical rib, compression of the subclavian artery may occur, with changes in the vessel and considerable circulatory disturbance in the extremity.

Contributory factors often are seen. The relative position of the shoulder girdle is high in infants and children, with gradual descent to the adult position. In females and in the aged, the descent is greatest, so that the shoulders droop considerably. An occupational factor sometimes is present. The patient works as a typist or as a housewife and has the pain while the arms are down at the sides; it subsides on rest and elevation of the arm.

A traumatic form of scalenus syndrome may occur. Following a fall or a twist of the shoulder, the patient develops pain over the shoulder, at the side of the neck, that radiates down the arm. Clinical and roentgen examination may disclose no evidence of muscular or bony lesions except for tenderness over the scalenus. A sprain or a strain of the muscle may be the initial lesion.

A secondary form of the scalenus syndrome occurs. A painful local lesion causes muscle spasm about the shoulder, and the scalenus anticus may participate in this spasm This accounts for the radiation of pain into the neck and down the arm to the wrist and the fingers that often accompanies bursal and tendon lesions

Symptoms and Findings. About half of the patients give a history of injury, with pain beginning immediately or after a lapse of a few hours The other half give no history of injury, the pain being mild at first and

the radial pulse and cause circulatory disturbances of the hand. An aneurysmal dilatation of the subclavian may occur distal to the point of compression.

Diagnosis. Cervical ribs often are found in patients who have no symptoms about the shoulder girdle, therefore, the presence of such a rib in a patient with pain about the shoulder and the arm does not indicate that the rib is the cause of the pain.* The diagnostic signs are (1) pain in the brachial distribution, (2) absence of a local cause of pain such as a muscular or a bursal lesion, (3) vascular disturbances, and (4) temporary abolition of symptoms by procaine injection of the scalenus anticus muscle. In order to make a reasonably certain diagnosis, other causes of pain must be excluded, such as subacromial bursitis with adhesions and calcareous deposits in the supraspinatus. Definite diminution in blood pressure and oscillometric demonstration of decreased arterial pulsation are significant. Infiltration of the scalenus anticus muscle with procaine solution (p. 171) should give temporary relief of symptoms.

Treatment. In most cases, complete relief of symptoms follows division of the scalenus anticus muscle at its insertion. This allows the subclavian artery and the brachial plexus to slide forward. In addition, the absence of scalenus action allows the first rib to drop downward slightly, and this further releases the compression. It is seldom necessary to resect the cervical rib itself, unless the rib or a fibrous prolongation comes forward to the scalene tubercle or manubrium.

* In a recent case there was pain in the right shoulder that radiated down to the hand. Roentgen study disclosed a cervical rib on the left side; none was present on the right. It would have been easy to attribute the symptoms to a right-sided cervical rib had one been found.

SHOULDER PAIN DUE TO LESIONS OF THE CERVICAL SPINE

In dealing with patients who have pain in the shoulder and the arm, the examination should include the cervical spine, especially if a definite cause for the pain does not appear in the examination of the shoulder and the scalenus. Hypertrophic arthritis of the cervical spine by irritation of the nerve roots at their exit from the vertebral canal may produce pain referred to the shoulder, the arm and the hand. The outstanding characteristic of this syndrome is the elicitation or the aggravation of the root symptoms on hyperextension of the cervical spine,[11,14,15] whereas flexion usually reduces or relieves the pain. An x-ray examination of the cervical spine aids materially in the diagnosis. Overhead traction usually gives relief.

Herniated cervical intervertebral disks also may be the cause of pain that radiates to the region of the scapula, the shoulder, the arm and the hand. Pain referred to a point just mesial to the upper angle of the scapula is an almost constant finding. Often there are associated sensory and reflex changes. The changes demonstrated by x-ray consist of the absence of the cervical lordosis and the narrowing of the particular cervical interspace. If conservative treatment with heat, immobilization or head traction does not give relief, hospitalization for operation may be necessary.

by injection. Marked hypertrophic changes in the cervical vertebrae, with narrowing of the intervertebral foramina through which the cervical nerves make their exit, can cause typical pain in the brachial distribution. In this condition, injection gives no relief, and oblique views of the cervical spine show the narrowed foramina.

Treatment. In very mild forms of the scalenus syndrome, benefit is obtained by rest, correction of faulty posture and exercise of the muscles of the shoulder girdle. The diagnostic procaine injection often gives relief for many hours or days, and in these instances repeated procaine injections, from 10 to 20 cc., may be of great value. When symptoms are severe, and when they recur quickly after procaine injection, division of the muscle at its insertion is indicated. This is indicated also when there is evidence of compression of the subclavian artery.

The operation can be performed under local anesthesia. A transverse incision is made 1 in. above the clavicle and about 3 in. long, centered a little lateral to the posterior border of the sternocleidomastoid muscle. The sternocleidomastoid is retracted, and the scalenus anticus is exposed by blunt dissection. The phrenic nerve can be seen coursing downward and medially over its anterior aspect. This must be displaced mesially with the vessels. The subclavian vein lies anterior to the insertion of the muscle. The muscle is dissected free, elevated with a flat instrument and divided carefully. All the dense fibrous tissue of the posterior sheath of the muscle should be cut. Then the subclavian artery can be seen behind the insertion. No deep sutures are needed; the fat and the skin are closed with sutures or clips. We have performed this operation on ambulatory patients without difficulty.

In the secondary forms of the scalenus syndrome, it is of prime importance to overcome the inciting lesion, such as chronic bursitis or calcareous deposits. Often no other treatment is needed.

CERVICAL RIBS

Anatomy and Etiology. Rudimentary ribs may be attached to the seventh cervical vertebra on one or both sides. In the most common form, the rib exhibits a head, a neck, a tubercle and a shaft 1 or 2 cm. long with a free ending. Less frequently, it is prolonged by a fibrous band extending to the scalene tubercle of the first rib; rarely is the rib complete and attached to the manubrium.

The subclavian artery and the brachial plexus arch over the first rib in the angle behind the scalenus anticus muscle and pass downward to the arm. When a cervical rib is present, the arching of the plexus and the artery may be increased, and the symptoms of compression of these structures may appear. Compression of the brachial plexus is manifested by pain in the brachial distribution, that is, the side of the neck, the shoulder, the arm, the forearm and the hand. The whole brachial distribution or only part of it may be involved. Thus, the pain may be felt over the shoulder, up the side of the neck and down the arm to the fingers; or there may be pain and paresthesias in the distribution of the lower cord of the brachial plexus, that is, the ulnar side of the forearm and the hand. Compression of the subclavian artery may be sufficient to diminish

This aids relaxation of the muscle, prevents it from being overstretched and relieves the pain to a considerable extent.

When the acute symptoms subside, home physiotherapy in the form of an electric pad or hot-water bottle applied to the painful area for from 15 to 20 minutes 3 times daily, followed by gentle massage with a 10 per cent methyl salicylate ointment, is prescribed. Active use should be started as soon as the acute symptoms subside, otherwise there are likely to be fibrosis and contracture of the involved muscles that result in loss of function.

We have had many satisfactory results from repeated procaine infiltrations of such injured muscles. The basis for its use is described under sprains (Chap. 26). The procaine solution should contain no vasoconstricting drug, and it should be given liberally, from 10 to 50 cc. as required. Active exercise of the part may start immediately. The infiltration may be repeated several times if necessary. Tendinitis of the long head of the biceps often responds very well to infiltration. The tissues about the bicipital groove should be well distended with solution.

Traumatic Dislocation of the Tendon of the Long Head of the Biceps

Etiology. The tendon of the long head of the biceps may be dislocated from the bicipital groove by violent exertion in which the forearm is flexed or by falls in which there is forcible external rotation. The tendon is displaced toward the medial side of the head of the humerus. Partial rupture of the short rotator tendons (p. 477) also may be present. The dislocation tends to reduce itself with a distinct snapping sound.

Diagnosis. The outstanding clinical findings in six cases[1] were:

> (1) swelling of the anterior aspect of the shoulder directly following the accident, (2) tenderness over the region of the long head of the biceps and the bicipital groove, and (3) limitation of motion and loss of strength in forward flexion and abduction. Pronation and supination of the forearm against resistance were painful, the pain being referred to the region of the bicipital groove. The outstanding feature, common to all six patients, was the "clicking" in the region of the bicipital groove which could be seen and felt on moderate abduction and lateral rotation of the arm
>
> Abduction with the arm laterally rotated is characteristically limited, and, if carried out passively, painful resistance is usually encountered. . . As the arm is carried from above the head to the side, when it reaches a point somewhat below the right angle, an audible or palpable snap may be evident which is associated with redislocation of the tendon . . Reduction is accomplished most easily by medial rotation with the arm at the side.

Treatment. Operation is required. The tendon may be fixed to the floor of the groove, or the fibrous roof of the groove may be reconstructed to prevent redislocation. The indications and the technic are described by Abbott and Saunders.[1] Hospitalization is necessary.

Rupture of Muscles and Tendons About the Shoulder

Etiology. Rupture of the muscles about the shoulder is not very common, it occurs more in the tendon of the long head of the biceps. Rupture is likely to take place when a contracting muscle is overstretched suddenly. The violence usually is great, except

LESIONS OF THE MUSCLES AND THE TENDONS

Acute Traumatic Myositis and Tendinitis

Etiology. Acute traumatic myositis and tendinitis occur quite commonly about the shoulder as a result of falls or twisting injuries that suddenly overstretch one or more muscles. Direct violence also may cause traumatic myositis, and in this type the lesion is essentially a contusion. The exact pathology present in a suddenly overstretched muscle is not always clear, there may be actual lacerations of some muscle or tendon fibers, but it is quite possible that these lesions are essentially functional and analogous to sprains of ligaments.

Symptoms. Immediately after the injury or within a few hours of it, there is an onset of pain over the muscles involved. This pain may be mild or severe The patient tends to carry his shoulder in a position that allows the affected muscle to be relaxed.

Diagnosis. The pain is well localized over the affected muscle, which is spastic and tender. There may be swelling of the muscle. Active motion is painful and restricted, and passive motion is restricted in the direction that stretches the muscle Thus, involvement of the trapezius muscle will result in pain on raising the shoulder actively and on passive depression of the shoulder or on flexing the neck to the opposite side. Involvement of the rhomboid muscles, which attach the scapula to the spinous processes of the upper thoracic vertebrae, causes pain when the patient pulls his shoulders backward and "throws out" his chest; also when the arm is elevated actively. Involvement of the deltoid muscle also gives pain on elevation of the arm. In each instance, the localization of the pain and the tenderness indicates the particular muscle involved. The pectoralis major and the biceps and the triceps muscle bellies are seldom affected. The tendon of the biceps, however, often is the site of an acute traumatic tendinitis. In this condition, there are pain and tenderness well localized over the bicipital groove at the anterior aspect of the shoulder, and aggravation is likely when the patient attempts to flex the forearm against resistance while raising the arm.

We have seen instances in which there apparently had been an active traumatic myositis of the scalenus anticus muscle, as judged from localized tenderness over the muscle and from pain on stretching the muscle, which can be done by rotating the head to the same side and hyperextending the neck. In these cases, there may be pain over the side of the neck and the top of the shoulder that radiates to the insertion of the deltoid or down the arm. This pain indicates some irritation of the brachial plexus, which lies immediately beneath the muscle (see section on scalenus anticus syndrome, p. 470).

Treatment. The general principles governing the treatment of any traumatic lesion apply to myositis and tendinitis Rest, immobilization pressure dressings when possible and application of cold during the first 24 to 48 hours after the injury usually are very helpful. The immobilization dressing must be made according to the needs of the patient. Usually, an adhesive strapping can be applied in such a manner that the origin and the insertion of the muscle involved can be drawn toward each other (Fig. 338).

out and becomes thinner and weaker. In older people who perform heavy labor, rupture of this tendon occurs quite often; the violence need not be very great. The tendon may rupture in younger individuals after a violent exertion, as in bowling. Partial rupture may result in elongation of the tendon, with findings similar to those in complete rupture. The diagnosis can be made from the history of injury, tenderness over the bicipital groove and the characteristic striking bulge of the muscle belly which appears at the lower end of the muscle when the elbow is flexed against resistance (Fig. 317).

Ruptures of the triceps, the coracobrachialis, the pectoralis major, the serratus magnus and the subscapularis muscles are very rare. The diagnosis may be made by the signs described above.

Treatment. When gross rupture of a muscle is demonstrable, operative treatment is the only method of value. The torn muscle or tendon must be sutured if function is to be restored. In elderly patients, rupture of the tendon of the long head of the biceps may be allowed to go untreated if function is not greatly impaired and if no heavy labor is required. In younger people, the ruptured long head is sutured to the short head at the coracoid process.[6]

Rupture of the Supraspinatus Tendon

The supraspinatus muscle originates from the supraspinous fossa of the scapula and passes beneath the acromion to insert into the greater tuberosity of the humerus. Its function is to help initiate elevation of the arm and, with the other short rotators, to hold the head of the humerus against the glenoid. The tendon of the supraspinatus fuses with the other short rotator tendons (Fig. 318) to form a cuff that inserts into the sulcus at the outer margin of the articular surface of the humerus. This cuff forms part of the floor of the subacromial bursa. The short rotator muscles serve to hold the head of the humerus against the glenoid as well as to rotate the arm. The fused tendinous cuff may be torn as a complication of fractures and dislocations about the shoulder; rupture of the supraspinatus tendon occurs also as an isolated injury. It is caused by the same mechanism that produces avulsion fracture of the greater tuberosity of the humerus; that is, sudden adduction of the arm while it is being elevated, so that an abrupt and a violent increase of tension on the tendon occurs. The rupture may be partial or complete.

Partial Rupture

Diagnosis. An intact supraspinatus is necessary for powerful elevation of the arm. Partial rupture weakens the action of the muscles and makes elevation difficult. The immediate symptoms are mainly those of an acute traumatic subacromial bursitis, manifested by pain, tenderness and swelling about the bursa. Muscle spasm is present, and this limits motion. In addition, there are likely to be a spot of acute tenderness just proximal to the greater tuberosity, weakness on attempting to raise the arm and pain when the injured area passes beneath the acromion. A fracture must be excluded by roentgen examination. During the acute phase, it is not easy to determine whether difficulty in raising the arm is due to pain and muscle spasm or to actual injury to the short



Fig. 347. Typical deformity produced by rupture of the long head of the biceps muscle. As the muscle is contracted, the belly, having lost its resistance due to rupture of the tendon of the long head, contracts and forms a bulge in the lower portion of the arm.

in occasional cases of *rupture of the tendon of the long head of the biceps* in elderly people. In them, the tendon may be so frayed by use that it gives way with little or no exertion. The point at which the muscle merges into its tendon is a common site of rupture. Less frequently, it occurs at the bony insertion of the tendon or through the muscle belly itself.

Pathology. Ordinarily, no disease of muscle is demonstrable as a contributory cause. The muscle tears irregularly at the site of laceration and retracts if the laceration is extensive. Contracture and fibrosis follow if the injury is not repaired.

Symptoms. During violent exertion in which the contracting muscle is overstretched, the patient feels a sudden snap and sharp pain. The pain continues, and the patient notices loss of power of the muscle affected. Contraction of the muscle involved produces a striking bulge of the muscle belly.

Diagnosis. When only a few fibers are torn, the condition essentially is that described under strains. Gross rupture of a muscle is followed by pain and tenderness at the site of injury. When the muscle is made to contract against resistance, a striking bulge of the belly becomes visible. This is true of the muscles placed superficially. When the muscles situated deeply, particularly the short rotators, are involved, the diagnosis must be made on the basis of pain, localized tenderness and loss of power. These will be considered in the section on rupture of the short rotator tendons.

Rupture of the deltoid is rare. Usually the diagnosis can be made from the history of injury, pain tenderness and a visible bulge in the muscle belly when the arm is elevated against resistance.

Rupture of the long head of the biceps in its tendinous portion is more common. The tendon of the long head passes upward in the bicipital groove and enters the capsule of the shoulder joint to insert in the upper margin of the glenoid. The head of the humerus slides on the tendon during elevation of the arm, and long-continued arduous use may result in attritional changes. The tendon frays

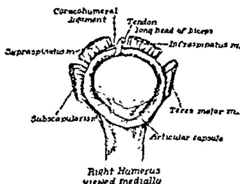


Fig. 348. Musculotendinous cuff about the neck of the humerus

out and becomes thinner and weaker. In older people who perform heavy labor, rupture of this tendon occurs quite often; the violence need not be very great. The tendon may rupture in younger individuals after a violent exertion, as in bowling. Partial rupture may result in elongation of the tendon, with findings similar to those in complete rupture. The diagnosis can be made from the history of injury, tenderness over the bicipital groove and the characteristic striking bulge of the muscle belly which appears at the lower end of the muscle when the elbow is flexed against resistance (Fig. 317).

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Treatment. When gross rupture of a muscle is demonstrable, operative treatment is the only method of value. The torn muscle or tendon must be sutured if function is to be restored. In elderly patients, rupture of the tendon of the long head of the biceps may be allowed to go untreated if function is not greatly impaired and if no heavy labor is required. In younger people, the ruptured long head is sutured to the short head at the coracoid process.[6]

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Partial Rupture

Diagnosis. An intact supraspinatus is necessary for powerful elevation of the arm. Partial rupture weakens the action of the muscles and makes elevation difficult. The immediate symptoms are mainly those of an acute traumatic subacromial bursitis, manifested by pain, tenderness and swelling about the bursa. Muscle spasm is present, and this limits motion. In addition, there are likely to be a spot of acute tenderness just proximal to the greater tuberosity, weakness on attempting to raise the arm and pain when the injured area passes beneath the acromion. A fracture must be excluded by roentgen examination. During the acute phase, it is not easy to determine whether difficulty in raising the arm is due to pain and muscle spasm or to actual injury to the short

rotator tendons. When partial rupture is suspected, the bursa may be infiltrated with procaine solution to abolish pain and spasm. If definite weakness of elevation remains, the patient should be treated for partial rupture.

As an alternative diagnostic procedure, the patient may be treated for acute subacromial bursitis until the acute symptoms subside. This takes perhaps 3 or 4 days. Then the patient is re-examined, and, if elevation is definitely weak and difficult, a diagnosis of partial rupture is made.

When partial ruptures are seen long after the injury, adhesions in the subacromial bursa often complicate the clinical picture.

Treatment. In addition to the measures commonly used for acute traumatic bursitis, the arm should be immobilized in partial or full abduction for at least 2 or 3 weeks, depending on the estimated extent of the rupture. When weakness of elevation and irregularity of the rhythm of motion are very slight, immobilization should be in moderate abduction through an abduction cast or a splint (Chap. 28) for a short period. When these findings are quite marked, full abduction for a long period of immobilization is desirable. After the period of immobilization, home physiotherapy and massage are indicated. Stooping exercises (Fig. 339) are of value in order to prevent bursal adhesions. If the symptoms persist after an adequate period of immobilization followed by exercises, the floor of the subacromial bursa should be explored through an incision as described in the operation for complete rupture of the tendon.

Complete Rupture

Diagnosis. If the patient is seen shortly after injury, the signs of acute subacromial bursitis may be present in addition to the inability to raise the arm from the side. This disability often is simulated by the pain and muscle spasm incidental to acute bursitis, and to rule out this lesion a procaine infiltration of the bursa to abolish the pain may be given. If the patient still is unable to lift the arm from the side, the diagnosis of extensive rupture is certain. If the rupture is not extensive, the patient may be able to abduct the arm in one position of rotation but not in another; that is, he may be able to abduct in full internal rotation and not in external rotation.[9]

When the patient is seen after the acute phase, other diagnostic signs are present. Although unable to lift the arm from the side, if it is passively elevated to the horizontal, the patient then can raise the arm to the vertical; this is due to the action of the deltoid The patient can lower the arm slowly from the vertical position until it becomes horizontal. At this point, he loses control of the arm, because of the absence of supraspinatus action, and the arm falls to the side. The total range of motion is diminished little, if at all. When the tuberosity passes beneath the acromion, there is apt to be a jog or a bump, which may be palpable and visible, and it is accompanied by a soft, gristly crepitus. Palpation of the shoulder may disclose a tender spot over the greater tuberosity of the humerus. The tuberosity may feel to be unduly prominent, and there may be a sulcus proximal to it at the point of laceration of the tendon. In cases of long standing, marked atrophy of the spinatus muscles may be present.

Treatment. When a diagnosis of extensive rupture of the supraspinatus

tendon is made, conservative treatment is not likely to be of value. However, since considerable improvement may follow subsidence of the acute symptoms in a week or two, and since repair may be difficult in the elderly patient due to extensive degenerative changes in the tendon, a definite decision often may be deferred for a short time.

Under local anesthesia, an anterior incision of from 5 to 7 cm. is made downward from the tip of the acromion. The fibers of the deltoid are separated, and the roof of the bursa is exposed, grasped with hemostats and incised. The crescentic tear in the tendon is visible in the floor of the bursa, and the torn edges are approximated with silk if a sufficient distal stump of tendon is present; otherwise, the proximal portion must be sutured directly to the greater tuberosity. A sharp heavy-gauge needle is used to drill 4 canals through the tuberosity into which the sutures are threaded. It may be necessary to bring the arm into some degree of abduction to secure approximation of the tendon to the tuberosity. The deltoid muscle is closed with plain catgut or silk sutures, and the skin is closed with sutures or clips.

The arm is immobilized at the side in moderate abduction by means of a thick axillary pad with a sling and a swathe dressing or an abduction splint. Passive exercises are started after 7 to 10 days, and active use is begun after 2 to 3 weeks, depending on the security with which the tear has been repaired. Without operation, prognosis for a good functional shoulder is very poor.

Calcareous Tendinitis at the Elbow

The etiology of this condition is discussed on page 462. It occurs occasionally at the external epicondyle of the elbow.



Fig. 349. Calcareous tendinitis of the internal epicondyle. The symptoms in this case disappeared following excision of the deposit under local anesthesia.

Diagnosis. There is a slow or a rapid onset of pain which may be related to some mild trauma. The pain grows worse and may be disabling. In mild forms, the condition resembles tennis elbow. However, roentgenograms will show a typical area of calcareous deposit at the external epicondyle (Fig. 349), and it is at this point that pain, acute tenderness and perhaps swelling will be found.

Treatment. Conservative treatment by procaine infiltration and multiple punctures of the area with a large-bore needle is likely to be effective. Roentgen therapy also may be of value. If these measures fail, evacuation of the deposit through a small incision will relieve the symptoms.

Tennis Elbow

Tennis elbow is the name given to a painful disability in the area of the external epicondyle of the humerus. In an effort to identify the syndrome with a pathologic process, the names epicondylitis, radiohumeral bursitis and radiohumeral synovitis often are used. In most cases the causative factor is repeated violent contraction of the extensor supinator muscles of the forearm which have their origin from the external epicondyle of the humerus.

Etiology and Pathology. Most commonly, tennis elbow in men is seen on the side used most. It is frequent in sports and occupations requiring extension and supination of the forearm—tennis, fly fishing, wringing clothes, etc. Some authors believe that these repeated strains at the origin of the common extensors from the epicondyle may result in an incomplete tear and a periostitis or an epicondylitis. It has been suggested that the symptoms are due to an inflammation in a bursa under the common extensor origin, but no bursa has been demonstrated in this area in the author's experience. Stark and Hunt[17] and others believe that tennis elbow is due in some cases to a synovitis of the radiohumeral joint. The pain is the result of the pinching of the synovium between the head of the radius and the capitellum when the arm is used with the elbow in extension and the hand is used to grasp objects.

Symptoms. The patient complains of pain and tenderness in the region of the lateral epicondyle. This pain is "accentuated" by grasping an object or making a fist with elbow and wrist extended and forearm pronated. Pain or soreness often radiates over the extensor muscles of the forearm A weakness in the grip and/or a pain when grasping appears, so that patients may drop inadvertently even such light objects as a cup; or there may be difficulty in the finer hand-and-finger movements, such as tying a tie or buttoning a shirt. Supination of the forearm with the hand in the grasping position, such as turning a door knob, causes acute pain.

Diagnosis. The gradual onset of pain associated with a specific activity requiring pronation-extension of the forearm is characteristic. Examination discloses a tender spot just below the external epicondyle or in the extensor group of muscles close to it. The elbow joint is normal, but there may be slight limitation of extension if the forearm is pronated. This condition may be tested. If the wrist and the fingers are flexed fully and the forearm is pronated, complete extension of the elbow is restricted and painful.[12] Supination of the forearm against resistance produces marked pain in the area of the elbow.

Calcareous tendinitis at the external epicondyle may simulate tennis elbow, but the pain is likely to be quite severe, and roentgenograms will show the characteristic calcareous deposit.

Treatment. Rest and immobilization will relieve the pain, at least temporarily. The forearm is splinted with the wrist in dorsiflexion and is suspended in a sling. If pain recurs persistently, one of three methods may bring relief. The manipulative and the operative methods of treatment are effective probably because a partial rupture of tendon fibers is made complete or because the tendinous insertion is lengthened by stretching or incision. Injection may be employed to produce a local inflammatory re-



FIG. 350. (*Top, left*) Primary axillary phlebitis in a young man 23 years of age. Note the swelling in the left arm. (*Top, right*) Infrared photo of same patient showing marked enlargement of the veins over the upper arm and the chest. (*Bottom*) Roentgenogram of injected veins showing block of the veins at about the costocoracoid membrane This patient was treated by injection of the stellate ganglion with marked improvement.

action at the site of the origin of the extensor group. As the inflammation subsides, the painful syndrome disappears gradually.

MANIPULATION. Mills[12] advises manipulation, particularly in chronic cases exhibiting limitation of movement. Under general anesthesia, he forces the elbow into full extension with the wrist and the fingers flexed and the forearm pronated. At the same time, firm pressure is made over the tender point with the thumb of the hand controlling the elbow. The

elbow may straighten with a click, or it may straighten gradually with continued effort. If the condition is not relieved completely, this procedure may be repeated after 4 days.

INJECTION. Slowick[16] reported 5 cases in which an injection of 0.5 cc. of 1 per cent procaine solution into the site under the tendon of the extensor group, followed by an injection of 0.3 cc. of 5 per cent sodium morrhuate solution, afforded marked relief. We have employed this method with good results.

HYDROCORTISONE. In the hands of several authors,[18] injections of hydrocortisone 25 mg. (1 cc.) at the most tender spot over the elbow have given almost immediate and complete relief of the symptoms of tennis elbow.

OPERATION. This may be advisable when other methods fail. Probably this was first performed to excise an inflamed radiohumeral bursa which was believed to be the cause of the pain; although no bursa was found, the symptoms were relieved. It appears that any operation in which the fibrous origin of the muscle is partly divided will relieve the pain.

Under local anesthesia, an incision is made over the external epicondyle, and the tendinous origin of the supinator-extensor muscles is incised. Often this will expose an area of denuded bone or a ganglionlike area of degenerated fibrous tissue, which may be scraped away with the edge of the knife. However, the essential curative effect seems to come from incision.

PRIMARY THROMBOSIS OF THE AXILLARY VEINS (EFFORT THROMBOPHLEBITIS)

Etiology and Pathology. The syndrome described under the name of primary thrombosis or effort phlebitis is a relatively infrequent one. It is a thrombosis or a phlebitis of the axillary vein (Fig. 350) which occurs almost invariably in robust individuals and more frequently in men than in women. The arm used most is the one affected most often. As a rule, the condition follows some unusual or sudden exertion of the arm. Thus, in the experience of the author, effort thrombosis occurred in an accountant following an all-night use of an adding machine; in the right hand of a butcher following a hard Saturday of work; and in the right arm of a young man who spent the evening bowling. In the literature, cases of spontaneous thrombosis are reported following an accidental strain of the arm.

The cause of the thrombosis is not too well known. In the earlier writings, it was believed that it was produced by a localized traumatic phlebitis, following a sudden stretch or compression of the axillary vein. It was suggested, on the basis of various anatomic dissections and by injecting the veins with plaster of Paris and radiopaque substances, that the vein was constricted in some people by the costocoracoid ligament, and that this constriction produced a rupture of one of the valves in the axillary vein with consequent secondary thrombosis. As a result of these studies, Veal and McFetridge[20] concluded that the constriction occurred below the head of the humerus and against the subscapularis muscle when the arm was in abduction.

It is fairly well accepted that infection is not a factor in the production of this type of phlebitis. *Cottalorda*[3] suggests that the syndrome starts with a spasm of the vein due to sympathetic irritation as the result of trauma.

He offered this theory because, in operating upon such patients, he found no clot present in the vein but simply a marked venous spasm.

Symptoms. The symptoms of this lesion are quite typical. Following some unusual or prolonged use of the arm, there is a sudden painless swelling of the entire arm without any systemic symptoms or any evidence of local inflammatory reaction. The arm usually is cyanotic and pits on pressure; the axillary vein usually is palpable as a firm, tender cord. There is early evidence of the development of a collateral venous dilatation over the shoulder and the chest. No serious consequences, such as embolism, have been reported from this type of thrombosis, but there may be considerable disability in the arm due to prolonged edema, weakness and stiffness of the part. The disability is increased following exertion, and recurrences have been known.

Treatment. May be divided into the conservative and the operative.

The conservative, which usually is tried first, consists of rest and elevation of the arm involved and the application of pressure bandages. The elastic adhesive bandage or the gelatin cast is most effective. The important therapeutic measure is to reduce and prevent further development of edema. Incisions have been made into the edematous arm with a rather rapid and marked improvement following the escape of the edema fluid.

The operative therapy of this condition is based on the belief that the irritation of the segment of vein involved produces reflex vasoconstriction in the arm. Removal of the focus of irritation by resection of the affected portion of the vein with or without periarterial sympathectomy, as suggested by Cottalorda,[3] has been advocated. Although the author never has had an opportunity to use this treatment, he believes that before resorting to operation it may be well to inject *the stellate ganglion. It is probable* that the same happy results may be obtained in this lesion as are obtained in thrombophlebitis of the lower extremity by injecting the lumbar sympathetic ganglion. In one case in which stellate ganglion injection was performed, extremely good results were obtained, with reduction of swelling and early resumption of normal function.

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Hand and Fingers

INFECTIONS

Paronychia

Acute Paronychia

Etiology. Paronychia is probably the simplest type of infection that involves the distal phalanx. It appears along the edge of the nail near the base (Fig. 351). Most often the infecting organism gains entrance into the space between the skin surface and the nail as a result of the pulling away or the biting off of hangnails or as a result of other trauma, such as received in manicures.

Progress of the Infection. For the first 2 or 3 days, the infection remains at the site of the original entrance of the infecting organism. A gradually increasing and painful swelling forms, and extends into the soft tissues at the side of the nail. As time goes on, the infection progresses proximally underneath the eponychium, thence across the fingernail to the opposite side. At







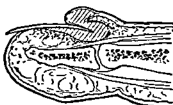


Fig 351 (*Top*). Paronychia underneath the eponychium on the lateral side of the nail

Fig 352 (*Right*) Paronychia. (1) The site of the abscess at the side of the nail (2) The infection has extended round the base of the nail. It has raised the eponychium but has not penetrated under the nail. (3) End stage of paronychia with a subeponychial and subungual abscess

first, the infection lies between the overhanging eponychium and the nail (Fig. 352, 1). It extends to undermine the nail at its base, a subungual collection is formed, with considerable swelling involving the tissues at the base of the nail and on each side. The laity commonly refer to this type of

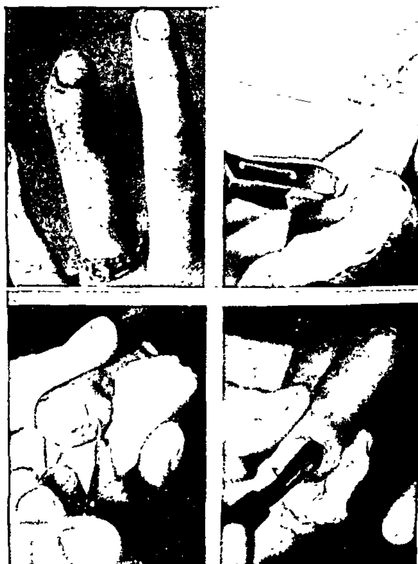


Fig. 353. (*Top, left*) Typical swelling of the soft tissues at the base of the nail in a paronychia that has extended into this area.

(*Top, right*) Drainage of a paronychia without anesthesia by inserting the tip of a knife along the nail edge and lifting away the eponychium from the nail. A drop of pus is evacuated from the abscess pocket.

(*Bottom, left*) Drainage of a paronychia. The tip of a knife is used to lift away the skin edge. Note the site of the abscess cavity at the side of the nail.

(*Bottom, right*) Drainage of a paronychia. A small sliver of rubber dam is inserted into the abscess cavity with the tip of a knife.

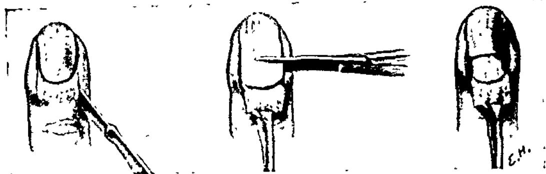


FIG. 351. Operation for drainage of a paronychia in which the infection has extended under the base of the nail. Lateral incisons are made through the eponychium, which is dissected away from the nail and turned back. The base of the nail is cut off with the knife or scissors to drain adequately the subungual abscess.

infection as a "runround." (Figs. 352, 2 and 3, and Fig. 353, *top, left.*)

Pathology. Almost invariably, the infecting organism is the *Staphylococcus aureus,* which tends to build up a wall of induration about it so that rapid spread of the infection is the exception rather than the rule. The relatively avascular abscess that forms contains pus, necrotic tissue and tremendous numbers of bacteria. Byrne[5] believes that the "organisms captured in these relatively impregnable foci, may persist despite high blood concentrations of the antibacterial agent."

Treatment. If the lesion is noted early, abscess formation may be aborted by the use of antibiotics to which the staphylococcus is sensitive. Since no culture or sensitivity tests are available, choice may be made among penicillin, Terramycin and erythromycin. The advantage the last-mentioned has is that it is used orally. Once an abscess has formed, early drainage of the primary focus of infection will permit a rapid subsidence of the inflammatory process and healing within a day or two

When there is definite swelling along the edge of the nail, the mistake often is made of incising the soft tissues at the side of the finger. No relief is experienced from such incisions, which we have seen made often, the patient being told that it was a matter only of some dark blood that had to be let out.

An understanding of the course of the infection makes it plain that drainage is obtained in the early cases simply by lifting up the skin edge from the nail (Fig. 353, *top, right*). This can be accomplished easily without anesthesia by inserting the tip of the scalpel carefully along the edge of the nail at the site of the swelling. A drop of pus escapes, and the patient experiences almost immediate relief of pain. The point of the knife should be carried along the nail to separate the skin over the tiny abscess sufficiently to provide adequate drainage. As a rule, a tiny pocket about as big as a match head will be found (Fig. 353, *bottom, left*). The overhanging superficial skin may be cut away with the knife edge without pain or bleeding. A sliver of rubber dam is inserted into the abscess pocket to permit continued drainage (Fig. 353, *bottom, right*). Hot wet compresses for 24 hours usually suffice to permit discharge of any remaining purulent

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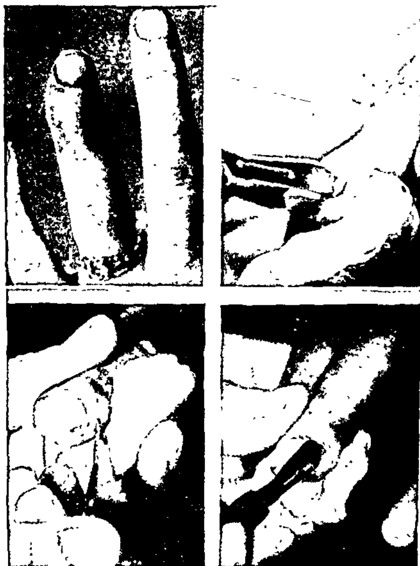


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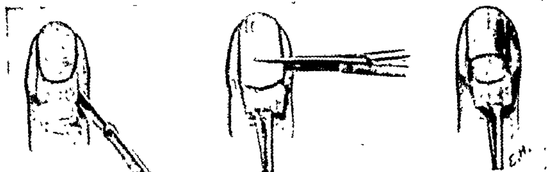


FIG. 351. Operation for drainage of a paronychia in which the infection has extended under the base of the nail Lateral incisons are made through the eponychium, which is dissected away from the nail and turned back. The base of the nail is cut off with the knife or scissors to drain adequately the subungual abscess.

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material At the end of this time, the drain may be removed, and simple dry dressings are applied until healing takes place. Usually, all bandages may be removed in 3 or 4 days, when symptoms have disappeared.

When the paronychia has extended underneath the eponychium at the base of the nail, the same procedure may be carried out. If, however, the infectious process has extended to invade the subungual space, adequate drainage cannot be obtained without excising the base of the nail (Fig. 351). To accomplish this, incisions must be made through the eponychium parallel to the lateral edges of the nail. These incisions are carried downward to permit the eponychium to be turned back to expose the nail base. As much of the nail base as is undermined with pus is excised, the scalpel or scissors being used. The abscess pocket under the eponychium is packed with petrolatum gauze, and a voluminous dressing is applied. Hot moist solutions are applied by dipping the finger in a cup or a glass with the dressing still in place; this permits continued drainage. The dressing should not be changed until the second day, when the packing may be removed and the eponychium permitted to fall back in place. The distal portion of the nail should not be removed, since it offers good protection, and gradually it is pushed off as the new nail grows in place. This takes several weeks.

In a few cases, infective hypertrophic granulations appear at the site of the abscess underneath the eponychium. These are extremely painful, and they can be prevented by snug bandaging. When they occur, pressure bandages will flatten down the granulation and healing will take place, except in a few cases in which it is necessary to excise a little more of the nail because its edge is cutting into the overhanging granulation and causing discomfort.

Antibiotic Therapy. Since these almost always are staphylococcal infections, the use of penicillin, Terramycin or erythromycin seems to be logical. As a matter of fact, the antibiotics add very little to the control of the infection, and they do definite harm if they delay surgical drainage of the purulent collections.

Before leaving the subject of acute paronychia, it should be stressed that primarily these are infections of the dorsum of the finger, and they practically never invade the palmar surface. They have to do with the tissues round the nail, and, in spite of swelling in the soft tissues at the side of the finger, the drainage can be accomplished most easily along the nail edge and the nail base.

Chronic Paronychia

Etiology and Symptoms. This is another common infection of the nail border; it produces a sluggish inflammation of the eponychium that gradually crosses the nail and involves the soft tissues on both sides. The eponychium becomes red and swollen and separates slightly from the nail. Beneath it appears a drop or two of serous purulent exudate, which dries and often crusts, causing slight discomfort

The cause of this infection may be either a low-grade staphylococcal infection or a ringworm. The long-continued infection underneath the eponychium produces an inflammatory reaction in the nail matrix, so that the nail often is roughened and pitted, and, in cases of ringworm in-

festation, it may have a moth-eaten appearance (Fig 355).

Treatment. The inflammation may subside with home treatment, hot soaks being used, but almost invariably it recurs. Usually, the patient does not seek treatment until home therapy has been tried unsuccessfully for several weeks.

In a few cases seen during the first week or two, antibiotics and hot moist applications may be tried for a time, but these usually are unsuccessful in effecting a cure. In such cases, roentgenotherapy is of definite value, and *often it is curative. However, in those* cases of such long standing that there is a necrosis of the base of the nail, conservative therapy no longer is of any value The necrotic-nail base acts as a foreign body and *produces a continued* exudate that cannot be relieved except by excising the nail base. This operation is the same as that described for acute paronychia. In cases in which the *chronic paronychia* is due to ringworm infestation, removal of the entire nail, followed by roentgenotherapy of the base, often is necessary.

Dermatitis Repens

Etiology and Symptoms. Dermatitis repens is the name given to a recurring pyogenic *infection that occurs most frequently on* the dorsum of the distal phalanx round the nail. It is seen also on the palmar surface of the fingers and the hand. It is characterized by a blisterlike elevation of the superficial layer of *skin containing* a purulent exudate (Fig. 87.) Culture of the pus most often shows a nonhemolytic streptococcus, although staphylococcus also may be found. When the superficial layer of the blisterlike swelling is removed, a small amount of liquid pus escapes, and the underlying unbroken true skin is seen to form the base of the lesion. Rupture of the blister does not permit healing. The *process tends to extend peripher*ally, with varying degrees of pain and swelling, and it may involve the skin of the dorsum of the finger from the nail to the proximal interphalangeal joint. On the palmar surface of the finger, the infection starts most often round the tip near the nail, in the same sort of blisterlike swelling. Because of the rich nerve supply to this

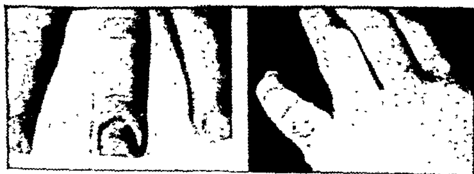


Fig. 355 (*Left*) Chronic paronychia. Note the thickening of the tissues of eponychium and the roughened appearance of the nail.

Fig 356 (*Right*). Furuncle of the dorsal surface of the proximal phalanx. Note the marked swelling of the proximal phalanx and of the adjacent web between the fourth and the fifth fingers.

area, tenderness is a common symptom.

Treatment. The important primary therapeutic measure for this type of infection is to obtain adequate and complete drainage by cutting away the entire detached area of superficial skin. Any overhang of epiderm left will permit the progress of the infection, which probably is an anaerobic one, and tends to extend underneath the protective layer of dead skin.

The prognosis for these cases is good. It is probable that the infection is self-limiting, but often it is slow in healing and is of considerable discomfort to the patient and anxiety to the surgeon. Systemic antibiotic therapy may be used, and, as a local application, bacitracin in concentration of 1,000 units per cc. may be tried. Culture and sensitivity tests permit the choice of the most effective antibiotic.

Furuncles of the Dorsal Surface of the Proximal Phalanx

Etiology. The hair follicles and the sebaceous glands of the dorsal surface of the proximal phalanx are common sites of origin for furuncles (Fig. 356). Often these are caused by wearing dirty gloves, the infecting organisms being ground into the hair follicles and the gland openings. The infection begins as a small red, tender area and extends to the subcutaneous tissues. Usually, pain and swelling are considerable. Not only does the infection involve the dorsal surface of the proximal phalanx, but it extends also to the adjacent loose tissues of the dorsum of the hand.

Treatment. As a rule, conservative therapy is of value, at least until definite pointing takes place. Almost always the infecting organism is a staphylococcus, which tends to produce a localized inflammation if the part is immobilized and hot moist dressings are applied. Therefore, the application of a finger splint and sufficient gauze dressing overlaid with waxed paper to give almost constant heat is indicated (Fig. 56). The hand is elevated in a sling, and the dressings are moistened at intervals of 2 or 3 hours with warm boric acid or saline solution. At the end of 24 or 48 hours, definite localization usually appears. The edema of the dorsum of the hand disappears, and in many cases it may be possible to delay any radical surgery until spontaneous separation of the necrotic core takes place. If this method of therapy is decided upon, splinting and hot moist dressings are continued for another day or two, at the end of which time drainage of the furuncle will take place spontaneously, and the central area of necrosis may be picked out with forceps. Hot moist dressings are continued for another 48 hours, when a simple dressing without splinting is all that is necessary.

Since this is an ordinary furuncle caused by the staphylococcus, it would be expected to show rapid response to antibiotic therapy, and this is true. Penicillin obviously is the antibiotic of choice, and it is given best in a combination of 500,000 units of aqueous penicillin plus 300,000 units of the slowly absorbed preparation administered every day until the inflammatory reaction has subsided. If the infecting organism appears to be resistant to penicillin, sensitivity tests may be used to determine the appropriate antibiotic. In the experience of the author, effective results usually are obtained from large initial doses of penicillin. If a change of antibiotic

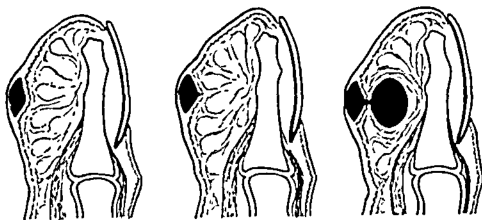


FIG. 357. Epidermal abscess. Located between the layers of the skin, this abscess may extend through the true skin and form a subdermal abscess when the skin over the fingertip is thick. This is a form of collar-button abscess.

seems to be indicated, erythromycin is preferred. The availability of the antibiotics and their great help in the treatment of infection do not mean that the methods of therapy previously used can be abandoned. If the antibiotics are used early, they may abort the infective process and prevent necrosis and suppuration. When they are not used until necrosis and pus already are present, incision and drainage still are necessary.

If incision and drainage are decided upon, a general or a local anesthesia may be used. If local anesthesia is chosen, cutaneous injections are made in longitudinal and transverse lines across the center of the infected area Care should be taken not to apply pressure as the incision is made, otherwise considerable pain may be produced. A crucial incision is made, and whatever loose necrotic tissue is present is picked away with the forceps. In spite of its appearance, none of the skin should be cut away. The wound may be packed with petrolatum gauze. Hot moist dressings are continued until all the sloughing tissue has come away, when pressure dressings held in place with adhesive are all that is necessary.

Furuncles of the dorsum of the proximal phalanx are similar to furuncles elsewhere on the body. They practically never involve the underlying tendon, although at times they extend laterally in the soft tissues of the finger. There never is any reason to incise the swelling on the dorsum of the hand.

EPIDERMAL OR SUBEPITHELIAL ABSCESS

Etiology and Symptoms. Injuries to the superficial layer of epithelium, such as a paper cut, a pinprick or other similar trauma in which there is a minute skin wound, may deposit bacteria between the layers of the skin. They here form a small abscess which lies under the tough outer layer of the skin and appears as a whitish or a yellowish blisterlike elevation. These infections occur most often in the finger on the palmar surface of the distal phalanx. As the process extends under the tough epithelium, pain, tenderness and swelling increase.

Treatment. If the infection is seen and recognized at this time, it can be aborted easily simply by excising the superficial layer of skin. This can be done without anesthesia by inserting the tip of the knife into the blisterlike swelling. A few drops of pus escape, the superficial layer of skin collapses, and excision can be done with scissors and forceps.

The danger from epidermal abscess is that the infection, being unable to reach the surface through the tough epidermis, may perforate the softer underlying dermis and extend into the pulp of the finger (Fig. 357). Thus there is formed a collar-button type of abscess, the superficial portion lying between the layers of the skin connected by a narrow opening to a subdermal abscess. After excising the top layer of skin covering the epidermal abscess, the base of the abscess is sponged carefully, and then pressure is made upon the pulp of the finger. If a subdermal abscess has formed, a drop of pus will be seen emerging from the site of the perforation of the dermis. It is important that the subdermal abscess be drained also. This may be accomplished by inserting *a fine-pointed mosquito* hemostat through the narrow opening, which is dilated sufficiently to permit evacuation of the contents of the underlying pus collection. Although this is a painful procedure, anesthesia usually is not necessary.

After drainage of an epidermal abscess or of its subdermal extension, hot wet dressings should be applied to the finger for a period of from 18 to 72 hours. By this time, most of the inflammatory reaction has subsided, and a simple protective bandage is all that is necessary until healing is complete.

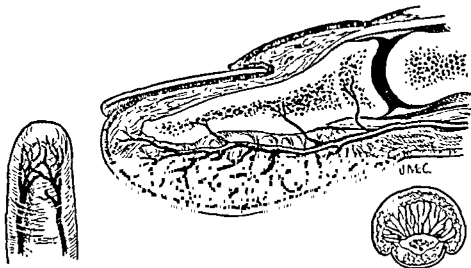


FIG 358. (*Top and Left*) Longitudinal section of the distal closed space, showing the blood supply. Note that the distal portion of the pulp of the finger is enclosed in a more or less definite fibrous capsule. One vessel enters the epiphysis of the phalanx; this portion of the bone almost never undergoes necrosis Note also the location of the flexor tendon, which is involved very late, if at all, in infections of the distal closed space. (*Lower Right*) Cross section of the distal closed space showing the formation of the fibrous tissue septa, in which are located pockets of fatty tissue.

INFECTION OF THE DISTAL CLOSED SPACE (FELON)

Anatomy and Pathology. The palmar surface of the distal half or two thirds of the distal phalanx is spoken of as the distal closed space. This name is given because of the peculiar formation of the pulp of the distal phalanx (Fig. 358). Fibrous tissue septa extend from the skin to the periosteum of the phalanx in a manner which more or less shuts off the portion of the phalanx distal to the epiphyseal line from the remaining portion of the finger. The fibrous tissue septa enclose large globules of fatty tissue that pad and protect the distal phalanx and form the rounded portion of the fingertip. Included in this tissue are numerous small glands. The fibrous tissue septa are so arranged as to divide the fatty pulp of the finger into pockets, more or less definite in themselves and at least partially shut off from one another (Fig. 358). Although not anatomically correct, from a practical point of view one may consider the pulp of the fingertip as looking something like an orange that has been cut transversely, the center of the orange representing the bone and the orange skin representing the skin of the finger. The divisions between the orange sections represent the fibrous tissue septa, and the pulp of the orange represents the fatty tissue included between them.

This conception of the distal closed space offers anatomic explanations for various clinical and pathologic findings in infections of this area. Infection of the distal closed space rarely, or only in the late stage, involves the flexor tendon sheath which inserts at the epiphysis, that is, at the base of the phalanx and, therefore, proximal to the distal closed space. The epiphyseal part of the bone and the joint rarely are involved, except late in the process of an infection of the distal closed space. The enclosure of the distal portion of the soft tissues of the finger in a more or less definite fascial space explains the extreme pain produced by inflammatory swelling in the early stages of infection in this area; and it also explains the fact that tension produces an early obliteration of the blood supply, not only to the soft tissues, but also to the diaphyseal portion of the phalanx, producing rapid necrosis of both the soft tissues and the bone. It is for this reason that early incision, with relief of tension, is important in the treatment of infections of this area

Symptoms and Progress of the Infection. The usual source of infection is some minor injury such as a pinprick, although frequently no injury is remembered by the patient. The infecting organism usually is the staphylococcus or the streptococcus. As a rule, 2 or 3 days elapse between the time of the injury and the appearance of a sticking sensation when the fingertip is touched. This gradually progresses to a constant pain, at first minor in nature, then becoming constant and throbbing in character. The throbbing is more marked when the finger is dependent, so that the patient often goes about with the hand inside the lapel of his coat. The pain usually is sufficiently marked to prevent sleep at night, and it continues until the death of the nerve supply to the fingertip, when the throbbing pain stops suddenly and a simple soreness takes its place. This is a late stage of felon and indicates extensive necrosis of the tissues of the distal closed space.

Treatment. If the infection is seen and recognized at this time, it can be aborted easily simply by excising the superficial layer of skin. This can be done without anesthesia by inserting the tip of the knife into the blisterlike swelling. A few drops of pus escape, the superficial layer of skin collapses, and excision can be done with scissors and forceps.

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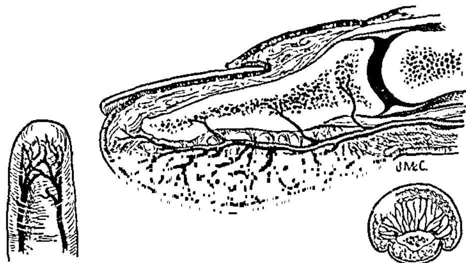


Fig. 358. (*Top and Left*) Longitudinal section of the distal closed space, showing the blood supply Note that the distal portion of the pulp of the finger is enclosed in a more or less definite fibrous capsule. One vessel enters the epiphysis of the phalanx; this portion of the bone almost never undergoes necrosis. Note also the location of the flexor tendon, which is involved very late, if at all, in infections of the distal closed space. (*Lower Right*) Cross section of the distal closed space showing the formation of the fibrous tissue septa, in which are located pockets of fatty tissue

INFECTION OF THE DISTAL CLOSED SPACE (FELON)

Anatomy and Pathology. The palmar surface of the distal half or two thirds of the distal phalanx is spoken of as the distal closed space. This name is given because of the peculiar formation of the pulp of the distal phalanx (Fig. 358). Fibrous tissue septa extend from the skin to the periosteum of the phalanx in a manner which more or less shuts off the portion of the phalanx distal to the epiphyseal line from the remaining portion of the finger. The fibrous tissue septa enclose large globules of fatty tissue that pad and protect the distal phalanx and form the rounded portion of the fingertip. Included in this tissue are numerous small glands. The fibrous tissue septa are so arranged as to divide the fatty pulp of the finger into pockets, more or less definite in themselves and at least partially shut off from one another (Fig. 358). Although not anatomically correct, from a practical point of view one may consider the pulp of the fingertip as looking something like an orange that has been cut transversely, the center of the orange representing the bone and the orange skin representing the skin of the finger. The divisions between the orange sections represent the fibrous tissue septa, and the pulp of the orange represents the fatty tissue included between them.

This conception of the distal closed space offers anatomic explanations for various clinical and pathologic findings in infections of this area. Infection of the distal closed space rarely, or only in the late stage, involves the flexor tendon sheath which inserts at the epiphysis, that is, at the base of the phalanx and, therefore, proximal to the distal closed space. The epiphyseal part of the bone and the joint rarely are involved, except late in the process of an infection of the distal closed space. The enclosure of the distal portion of the soft tissues of the finger in a more or less definite fascial space explains the extreme pain produced by inflammatory swelling in the early stages of infection in this area; and it also explains the fact that tension produces an early obliteration of the blood supply, not only to the soft tissues, but also to the diaphyseal portion of the phalanx, producing rapid necrosis of both the soft tissues and the bone. It is for this reason that early incision, with relief of tension, is important in the treatment of infections of this area.

Symptoms and Progress of the Infection. The usual source of infection is some minor injury such as a pinprick, although frequently no injury is remembered by the patient. The infecting organism usually is the staphylococcus or the streptococcus. As a rule, 2 or 3 days elapse between the time of the injury and the appearance of a sticking sensation when the fingertip is touched. This gradually progresses to a constant pain, at first minor in nature, then becoming constant and throbbing in character. The throbbing is more marked when the finger is dependent, so that the patient often goes about with the hand inside the lapel of his coat. The pain usually is sufficiently marked to prevent sleep at night, and it continues until the death of the nerve supply to the fingertip, when the throbbing pain stops suddenly and a simple soreness takes its place. This is a late stage of felon and indicates extensive necrosis of the tissues of the distal closed space.

Treatment. If the infection is seen and recognized at this time, it can be aborted easily simply by excising the superficial layer of skin. This can be done without anesthesia by inserting the tip of the knife into the blisterlike swelling. A few drops of pus escape, the superficial layer of skin collapses, and excision can be done with scissors and forceps.

The danger from epidermal abscess is that the infection, being unable to reach the surface through the tough epidermis, may perforate the softer underlying dermis and extend into the pulp of the finger (Fig. 357). Thus there is formed a collar-button type of abscess, the superficial portion lying between the layers of the skin connected by a narrow opening to a subdermal abscess After excising the top layer of skin covering the epidermal abscess, the base of the abscess is sponged carefully, and then pressure is made upon the pulp of the finger. If a subdermal abscess has formed, a drop of pus will be seen emerging from the site of the perforation of the dermis. It is important that the subdermal abscess be drained also. This may be accomplished by inserting a fine-pointed mosquito hemostat through the narrow opening, which is dilated sufficiently to permit evacuation of the contents of the underlying pus collection. Although this is a painful procedure, anesthesia usually is not necessary.

After drainage of an epidermal abscess or of its subdermal extension, hot wet dressings should be applied to the finger for a period of from 48 to 72 hours. By this time, most of the inflammatory reaction has subsided, and a simple protective bandage is all that is necessary until healing is complete.

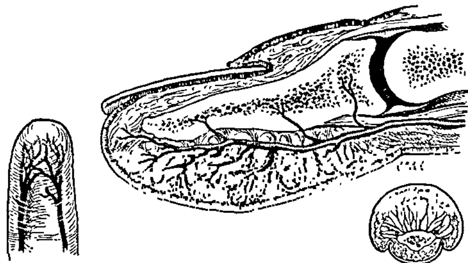


Fig 358. (*Top and Left*) Longitudinal section of the distal closed space, showing the blood supply. Note that the distal portion of the pulp of the finger is enclosed in a more or less definite fibrous capsule. One vessel enters the epiphysis of the phalanx; this portion of the bone almost never undergoes necrosis Note also the location of the flexor tendon, which is involved very late, if at all, in infections of the distal closed space. (*Lower Right*) Cross section of the distal closed space showing the formation of the fibrous tissue septa, in which are located pockets of fatty tissue.

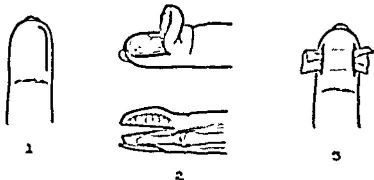


FIG. 361. Incisions for drainage of an abscess of the distal closed space. (1) Hockey stick incision, which can be employed when the abscess is demonstrated definitely to lie in the lateral side of the space. it should not be used unless the abscess can be located accurately. (2) Fishmouth or horseshoe incision, which gives the most adequate drainage. Although it may seem to be radical, nevertheless it gives excellent results. The soft tissues of the finger should be incised directly in front of the bone, as noted in the illustration. the incision should not be carried below the distal closed space because of the danger of entering the sheath of the tendon. (3) Through and through type of incision for drainage of the distal closed space. In the author's opinion, this incision does not give adequate drainage, therefore, it is not as safe as the fishmouth incision for general use

tube tourniquet then is applied round the base of the finger; hence no epinephrine is needed in the procaine (Fig. 360). In operating under local anesthesia, the common fault is to incise too quickly, that is, before the anesthesia is complete. A period of 5 minutes or longer should be allowed to elapse between the injection and the application of the tourniquet and the incision. One of several types of incision may be used, depending upon the site of the involvement of the finger pulp.

HOCKEY-STICK INCISION. If the area of infection appears to lie to one side or the other of the fingertip, a hockey-stick incision may be made; it should extend halfway across the finger, just in front of the nail and downward along the side of the phalanx (Fig. 361, 1). After waiting for a few minutes to sponge away the few drops of blood that have remained in the finger, the edges of the wound are separated sufficiently with Allis forceps or tiny rake retractors to visualize the yellowish area of necrosis at the site of the infection. If any necrotic tissue is loose, it is removed with forceps, when a small piece of petrolatum gauze is inserted for drainage.

THROUGH-AND-THROUGH INCISION. Another incision recommended by many surgeons is the through-and-through type. An incision is made on each side of the finger, and these are connected by severing the connective tissue septa between the skin and bone. A rubber-tissue drain is inserted through the opening thus made (Fig. 361, 3).

HORSESHOE OR FISHMOUTH INCISION. In spite of many objections found in the literature, the author believes that the more radical curved, or horseshoe, or fishmouth incision made anterior to the nail is the safest one for general use in infections of the distal closed space (Fig. 361, 2). The objections to it are that the wound takes a long time to heal, and that it produces a deforming scar of the fingertip, which is sensitive and, therefore, disabling



Fig. 359 Felon of the thumb Note the swelling and the mark where a piece of steel wool entered the fingertip. In cases of this sort, in which the abscess can be located definitely, the hockey stick incision can be used

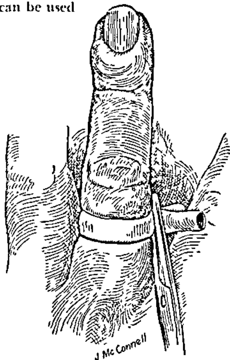


Fig. 360. In all operations on the distal portion of the finger, a tourniquet should be employed at the base of the finger. A small rubber tube placed on tension and held with a hemostat serves this purpose well.

Diagnosis. On examination of the finger in the earlier stages, one finds a swelling of the distal phalanx as compared with the normal finger on the opposite side. It is dusky red in color, and, if the finger is examined with the point of a pencil or some other blunt object, there usually is one area in which pressure gives exquisite tenderness (Fig. 359). This represents the area of skin that overlies the infected portion of the finger pulp. As the process goes on, this local area of tenderness becomes less definitely located, and, in the late stages, a simple sac of pus may be found underneath the skin of the distal phalanx. There usually is only slight swelling of the remaining portion of the finger and no involvement of the tendon, as evidenced by ability to move the finger without marked pain.

Treatment. Early and adequate incision is the key to the prevention of finger deformity and disability. In the early stages, when there is only a slight sticking sensation or tenderness at the site of infection, abortive therapy may be attempted by the use of cotton moistened in boric acid or saline held in place with a rubber fingercot, combined with antibiotic drugs (penicillin, erythromycin). If these drugs are to be effective, they should be used in large doses so as to obtain an early high blood concentration. This may be continued for from 12 to 24 hours, but the finger should be seen and examined at least once during this period. An incision for drainage is warranted in the case of any patient who exhibits a point-pressure tenderness after a sleepless night.

The operation is performed under local anesthesia injected at the base of the proximal phalanx. (See finger block anesthesia, page 44.) A rubber-

tant requisite, and neglect of which is the chief fault in the handling of fingertip infections. When the fishmouth incision is made, it is carried downward about two thirds of the distance to the distal flexion crease. This flap thus turned back exposes the area of necrosis in the pad of the fingertip. Necrotic tissue may be removed in large measure and the wound filled with sulfanilamide. A strip of rubber dam or petrolatum gauze is inserted across the phalanx, and a firm dressing is applied. In felons, although the infection extends early to the bone, usually there is no necessity for scraping or curetting the bone in the early or even the moderately advanced cases. No matter what incision has been made, a snug finger bandage is applied, and a hairpin splint is used to immobilize and protect the area of inflammation. After 2 or 3 days, the packing is removed, and the tissues are permitted to fall together. The dressings are somewhat painful until the slough is separated and granulation begins to form. Nevertheless, mechanical cleansing is the essential therapeutic measure. This can be done gently by irrigation with boric solution or saline in a syringe. What loose tissues appear to remain attached may be removed with forceps and scissors without great discomfort. Warm boric acid or saline solution is applied to the dressing every 2 or 3 hours until the slough is separated completely. In the later stages of the treatment, snug dressings are of considerable help in preventing swelling and edema and in promoting healing without excess granulation and scarring. Antibiotic therapy is continued in adequate dosage, even though incision has been performed. Unquestionably, by its use the infection is controlled more rapidly and the painful inflammation is reduced.

In the late stages of an acute felon, the entire pulp of the fingertip appears to be a mass of necrotic tissue and pus (Fig. 362). The bone often lies free in this abscess cavity, and in children the entire diaphysis may be raised from the epiphysis. If the bone is loose, it should be removed, but no effort should be made to curet or rongeur away any bone that is firmly attached. Without exception, the incision of choice in this type of case is the fishmouth. After removing the necrotic material, a petrolatum pack is inserted. It is wise to avoid excision of any skin tissue, except the thickened outer layer, which often becomes loose in the succeeding days of hot soaks.

It is surprising to see the amount of regeneration which takes place following drainage of a distal closed space. In many patients, even those with marked necrosis of the soft tissues and with definite osteomyelitis, as shown by roentgenograms, regeneration takes place to such an extent that a phalanx with almost normal function may be expected (Fig. 363).

Human-Bite Infections

Infections Caused by Actual Bites of the Fingers

Etiology and Symptoms. Human-bite infections of the fingers are due to two chief causes. The first is the actual biting of the finger by another person. In our experience, this has occurred most commonly in Negroes, who have been bitten during an altercation and in attendants in psychiatric institutions who have been bitten by patients. The wounds produced are ragged and contused, and they are in-



Fig. 362. Neglected felon showing loss of almost all the tissues of the distal phalanx.

for a short time. These objections seem to be more theoretical than real. If the packing or the drain is removed from a fishmouth incision in 2 or 3 days and the tissues are allowed to fall together, healing takes place with a minimum of scarring and almost as rapidly as is the case with the less radical incisions. The resulting deformity of the finger depends not so much upon the type of incision as upon the extent of the infectious necrotic process.

This incision gives the most adequate drainage, which is the impor-

Fig. 363. (*Left*) Marked osteomyelitis with degeneration and disappearance of a large part of the distal phalanx. (*Center and Right*) Regeneration of the distal phalanx that occurred in a period of 6 weeks This patient was sent to the author with the idea that the distal phalanx should be amputated. The insurance company was persuaded to delay any radical therapy, with the result that the patient has an almost normal phalanx after regeneration of the bone. After débriding the wound, conservative treatment with petrolatum pack and simple dressings was used.



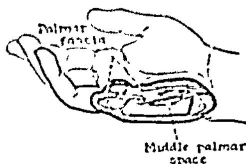


FIG. 361. (*Left*) Collar button abscess under a callus at the base of the ring finger. Note the surrounding swelling with extension into the web of the finger. (*Right*) Collar button abscess in cross-sectional view. The abscess between the layers of the skin had perforated through the true skin and extended into the loose connective tissue space in the web of the fingers. It tends also to extend along the lumbrical canal toward the palmar space.

follows injuries sustained while fish or shellfish was being handled or cleaned. It also is a frequent infection in butchers and veterinarians. We have seen numrous veterinary students with this infection following minute injuries at the dissecting table. The infection occurs almost entirely on the fingers and the hands; it appears 2 or 3 days following the injury as a burning red area at the site of the injury. It extends as a bluish-red inflammation of the skin. The edge of the inflammation is fairly well marked, but it is never as sharp as is the case in erysipelas, nor is the skin reaction as flaming (see p. 130).

Symptoms. There usually are few systemic symptoms, but the local burning, itching and aching makes the disease a disabling one. Frequently, there is a spread of the infection from one finger along the web to another, the site of the original infection tending to return to normal.

Treatment. In treating erysipeloid, immobilization probably is the most important local therapeutic measure. So long as movement of the finger is permitted, extension of the infection may be expected. Although the disease usually is self-limiting, this simple measure appears to shorten its course and to produce relief of local symptoms. Penicillin is extremely effective in this disease. With adequate dosage the infection usually subsides almost completely in 24 hours. In 2 or 3 days, the drug may be discontinued. It is rarely necessary to use the swine erysipelas serum.[34]

Collar-Button Abscess

The collar-button type of abscess denotes a definite infectious process that occurs almost entirely on the hands and the feet. The name is given the lesion because of the similarity of its shape to that of a collar button. Is is composed of a superficial abscess lying between the layers of the skin, usually underneath a callus, and con-

fected by the common pyogenic and saprophytic organisms of the mouth. As a rule, these wounds are not seen for treatment until 1 or 2 days have passed, when the finger is swollen markedly, often with associated lymphangitis. There is a yellowish-gray discharge with a characteristic foul odor. A culture of the pus usually shows streptococci, staphylococci and the spirillum and the fusiform bacillus of Vincent.

Treatment. If the wound is seen early, adequate cleansing with soap and water and excision of devitalized tissue to produce adequate drainage are necessary. Penicillin is given in large doses, often it is combined with one of the broad-spectrum antibiotics, such as Aureomycin. Usually, however, the patient is not seen until the infection is well established, when the entire finger and often the tendon sheaths are involved. Penicillin in large doses often produces remarkable results in these cases. When necrosis and pus are present, incision and drainage under general anesthesia are necessary. Zinc peroxide[28] is an excellent local application. If it becomes necessary to amputate the useless finger, it is best perhaps to delay this until the infection is controlled.

Infections Caused by a Blow on the Teeth by the Fist

Etiology and Symptoms. The second *type of human-bite infections* is that obtained from a blow on the teeth by the fist. This infection has been studied extensively and described by Mason and Koch,[27] who feel that wounds made over the knuckles by a blow upon the teeth cause organisms to be implanted in the metacarpophalangeal joint or in the subaponeurotic space in the region of the joint. With extension of the fingers, anaerobic conditions are produced by the proximal movement of the skin and the tendinous wound. The inadvertent cleansing and suturing of the tendon and the overlying skin may further enhance the anaerobic state. Usually, within 24 to 48 hours, swelling and pain in the region of the wound are marked.

Treatment. The clinical course of the infection varies from this point, depending upon the treatment. If *prompt and adequate drainage* is given, the process may subside. Penicillin in adequate dosage is almost a specific. Frequently, however, the infection extends upward along the sides of the finger or involves the bone or the joint; or it may even extend anteriorly along the interosseous muscles to the palmar spaces.

In treating joint infections of the knuckles, it must be borne in mind that these are highly infected wounds, and that suture never *should* be attempted. Careful cleansing of the wound with excision of devitalized tissues should be the rule, and the prophylactic use of penicillin is advisable. Immobilization, hot moist dressings and elevation should be prescribed.

In late cases, wide incision is necessary, including all areas in which pressure demonstrates the extension of pus from the original site of infection. The use of penicillin and immobilization gives the best results *in effecting* a rapid subsidence of the infection and avoiding disabling complications.

Erysipeloid

Etiology. Erysipeloid is an infection produced by the bacillus of swine erysipelas *(Erysipelothrix rhusiopathiae).* The organism is widespread in nature, but most often the infection

progress, the infection extends along the lumbrical canals to the middle palmar space or, less frequently, to the thenar space, in which case the abscess appears at the web between the index and the middle fingers (Fig. 364, *right*).

Treatment. The treatment of collar-button abscess is relatively simple if operation can be performed at an early date, that is, before the fascial spaces of the palm are invaded. With a tourniquet controlling the blood flow, usually under general or a local block anesthesia, the thick superficial skin overlying the intradermal abscesses is excised (Fig. 365). When the pus has been sponged away, gentle pressure is made round the floor of the abscess, and a drop or two of pus may be seen escaping through the sinus which pierces the true skin. Using this sinus as a guide, a pointed hemostat is inserted and spread as it is removed. Usually, considerable thick material escapes and, when it is sponged away, the extent of the abscess may be seen. Often it is advisable to incise the skin of the web of the finger to open the abscess pocket completely.

The wound may be packed gently with petrolatum gauze to control bleeding. A firm dressing and a splint to immobilize the palm and fingers on each side of the abscess complete the dressing.

As a rule, the dressing is not changed for 2 or 3 days, when the packing may be removed and a simple dressing applied; splinting should be maintained for 4 or 5 days longer. Hot solutions of saline or boric acid applied to the dressing prevent crusting and permit the continued drainage of pus.

In simple collar-button abscesses, healing usually occurs rapidly and without complication. The important thing is to make sure that the infection has not involved the middle palmar space. This is indicated by tenderness over the palm. By pressure over the area of the middle palmar space when the abscess is being redressed, the appearance of pus from the depth of the wound indicates an extension of the infection to the fascial space, and frequently a more adequate drainage is necessary. It is better usually to ensure adequate and complete drainage at the first operation, therefore, this investigation of the abscess cavity should be made at the time of the original incision. However, a close watch must be maintained to make sure that this extension of the infection does not occur at a later date.

The antibiotics are to be used in conjunction with and not instead of surgical therapy. They contribute to a more rapid subsidence of the inflammation and are worth while as a prophylactic against spread of the infecton to the palmar spaces.

Acute Suppurative Tenosynovitis

This lesion with its sequela is probably one of the most disabling of all infections of the hand, and for our knowledge of its pathology and treatment we are indebted largely to Kanavel,[16] whose pioneer work in this field has been oustanding.

Anatomy. To understand this infection, it is necessary to review briefly the anatomy of the tendon sheaths. Those of surgical importance from the standpoint of infection are the flexor tendon sheath. Kanavel pointed out that the tendon sheaths really were composed of two parts. An outer osseo-aponeurotic tunnel of dense fi-

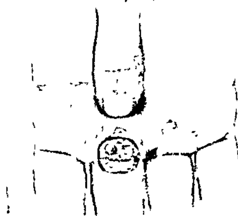




Fig 365. Drainage of a collar-button abscess. The callus has been cut away, which has unroofed the superficial, or epidermal, abscess. Pressure has produced a drop of pus at the site of perforation of the true skin. Drainage is accomplished by inserting a hemostat through this tiny opening to enlarge it and evacuate the deeper abscess.

nected by a small sinus through the true skin to a subdermal abscess in the subcuticular areolar tissue. This type of abscess occurs wherever there is a thick layer of superficial skin, such as that occasionally seen on the finger, but more commonly over the calluses in the distal part of the palm at the base of the fingers.

Etiology. The focus of infection may be an injury, but more often one is not found, the infecting organism probably entered the skin through a small crack or abrasion which was unnoticed by the patient. The infecting organism usually is the staphylococcus or the streptococcus.

Symptoms and Course of Infection. A small intradermal abscess forms primarily; this occasions slight soreness but relatively few symptoms, at least at first. The hard thick layer of skin above the infected area does not permit the escape of purulent material, and, as a result, the infection tends to perforate through the deeper layers of skin and form a subcutaneous abscess. With this extension of the infection, which usually is in the web of the finger, there is a swelling between the fingers and in the dorsum of the hand adjacent to the abscess (Fig. 364, *left*) Pain is experienced when the hand is used, and the fingers are held in flexion, but the fingers can be moved actively and passively without pain except in the extremes of flexion and extension, when tension is placed upon the area of inflammation.

Then the patient begins to complain of tenderness and soreness, but not of the excruciating pain noted in the distal closed space infection, although the hand becomes relatively useless because of tenderness in the palm. If the process is allowed to

spreading infection, because, with involvement of the ulnar and the radial bursae at the wrist, all the tendons of the fingers become involved in the infection. Infection of the sheaths of the index, the middle or the ring finger at first tends to remain localized within the single tendon sheath, but if the process is allowed to continue, the tendon sheaths rupture and the infection extends, involving the fascial spaces of the palm. In the case of the index finger, the extension is to the thenar space, and from the sheaths of the middle and the ring fingers it is to the middle palmar space.

Etiology. Acute suppurative tenosynovitis of the flexor tendon sheaths of the fingers has been described by Kanavel as appearing in two clinical forms.

The first, usually caused by the staphylococcus, appears most often following crushing or lacerating injuries. It tends to produce an infection localized to a single finger, the local evidences of which are much more striking than the systemic reaction.

The second type, caused by the streptococcus, follows an injury which is apparently insignificant, such as a pinprick, a small wound, or even a single break in the skin. The infecting organisms are transmitted rapidly through the lymphatics to the underlying tendon. In this case, the progress of the infection is rapid, and, although local signs are present in the finger, the systemic reaction also is marked. Thus, the differentiation between a lymphangitis and a tenosynovitis often is difficult. In this type of infection, there is little tendency to form the adhesions common in staphylococcic infections, and the process progresses rapidly, extending in a relatively short time from the tendon sheath to the fascial spaces or to the bursae at the wrist.

Symptoms. The signs and symptoms on which the diagnosis of acute tenosynovitis is based are clear. The finger involved is swollen symmetrically and held in fixed partial flexion, not as in Figure 500, *right*. Excruciating pain is experienced by the patient on either active or passive movement of the finger. Finally, extreme tenderness is noted on palpation over the tendon sheath involved.

Most marked tenderness appears to be experienced on palpation of the proximal portion of the tendon sheath in the region of the metacarpophalangeal joint. In addition to these cardinal signs and symptoms, there is the usual swelling of the loose tissues of the dorsum of the hand adjacent to the infected finger and of the web of the finger on each side. The adjacent fingers also may be held in partial flexion, but they are not fixed rigidly as is the infected finger.

Treatment. Because infection within the tendon sheaths produces sufficient tension to shut off the meager blood supply of the tendon, death of these fibrous tissues is rapid. The key to successful treatment lies in early diagnosis and early incision.

For the incision and the drainage of a suppurative tenosynovitis, general anesthesia should be used and the field made bloodless with a blood-pressure cuff acting as a tourniquet. Inflation of the cuff to 200 or 250 mm. of mercury ensures a complete compression of the blood vessels, and, except for a few drops of venous blood noted at the time of the first incision, the operation can be carried on with almost a cadaveric dryness. This permits rapid and accurate work, which is so necessary if the digital vessels and nerves

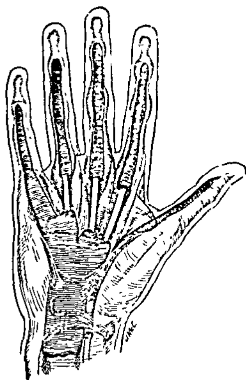




FIG. 366 (*Left*) Showing the location and the extent of the flexor tendon sheaths. (*Right*) Infection of the palmar surface of the finger *not* involving the tendon sheath. This patient was received with the diagnosis of an acute tenosynovitis, but the correct diagnosis can be made at a glance: the finger is not enlarged symmetrically, as in acute tenosynovitis, and the finger can be held in extension, whereas in acute tenosynovitis it is held in fixed flexon. This type of infection superficial to the tendon sheath offers an excellent prognosis with simple incision and drainage.

brous tissue overlies the tendon and binds it to the periosteum of the underlying phalanges. The inner layer of the sheaths is composed of the synovial membrane, which invests the tendons and forms a smooth surface on which they glide Batson[1] has taught for many years that these sheaths really are bursal spaces that develop due to pressure He shows that the flexor tendon sheaths may be outlined by pressure of the wet hand against a flat surface; the parts of the hand which wet the flat surface are those in which there are tendon sheaths

The sheaths begin in the fingers just distal to the distal interphalangeal joint and extend to a point about a thumb's breadth proximal to the web of the fingers (Fig. 366, *left*). Thus they extend for a short distance into the palm in the case of the index, the middle and the ring fingers. However, in the fifth finger and the thumb, the tendon sheaths extend toward the wrist and enter the ulnar and the radial bursae, respectively. It is for this reason that the tendon sheaths of the fifth finger and the thumb present a more dangerous and a more rapidly

lines the division between the major palmar spaces of the hand. Lying to the ulnar side of it are the flexor tendons of the middle, the ring and the fifth fingers, whereas the flexor tendons of the index finger lie to the thumb side. In this same plane with the tendons lie the vessels and the nerves of the hand. Between this layer of tendons and vessels and the interosseous muscles, which lie between the metacarpal bones on the ulnar side of the hand, is the middle palmar space Mesially, this space is bounded by the fascial attachment of the palmaris longus along the middle metacarpal bone. Laterally, it extends to the hypothenar muscles; distally, to within a thumb's breadth of the base of the fingers, and, proximally, to the base of the palm.

Lying to the thumb side of the fascial attachment of the palmar fascia to the middle metacarpal bone is the thenar space; it is between the tendons and the anterior surface of the adductor pollicis muscle. This muscle also takes its origin along the middle metacarpal bone, and the space then lies between it and the fascial attachment to the bone and extends toward the thumb through the tissues of the web of the thumb. These are the major spaces of the palm, and they are of most significance from the surgical point of view.

Middle Palmar Space Infection

Etiology. The middle palmar space may become infected as the result of an extension of a tenosynovitis from the middle or the ring finger, in which case the infection invades the space by rupture of the proximal portion of the tendon sheath and extends along the lumbrical muscle to the palmar space. Infection of the tendon sheath of the fifth finger rarely produces an infection of the palmar space, since it extends along the tendon sheaths to the ulnar bursa. Infection of the space may result also from injuries to the palm, such as lacerations or compound fractures or from extension of collar-button abscesses Finally, in neglected cases, the pus may rupture from an infection of the thenar space through the fascial plate separating the two spaces.

Symptoms and Diagnosis. Usually, the symptoms of infection of the middle palmar space are quite typical; remembering the routes by which infection may travel to it, the history often is helpful in making the diagnosis. On inspection, the fingers, especially the middle and the ring fingers, are held in partial flexion, although, except in cases of an extension from a tenosynovitis, fixed flexion is not present. Swelling is characteristic; there is a loss of the cavity of the palm, especially on the ulnar side, with swelling most marked at the distal portion of the palm between the middle and the ring fingers. This area of swelling represents the extension along the lumbrical muscle to the loose connective tissues in the web of the fingers. There is always a very marked edema of the loose tissues of the dorsum of the hand. This edema is soft, it pits easily, and it is due to the fact that the lymphatic drainage is from the palm to the dorsum by the shortest possible route. This edematous swelling never should be incised with the mistaken idea that the purulent process lies on the dorsum. Finally, tenderness is acute on slight pressure over the outline of the middle palmar space.

Treatment. To drain an infection of the middle palmar space, an incision is made in the distal palm be-

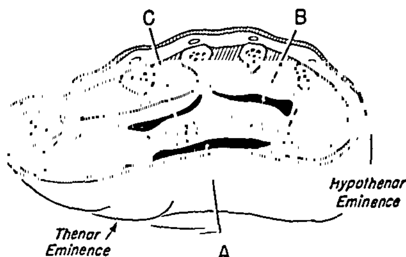


Fig. 367. Schematic cross section of palm of hand. (A) Pretendinous space of Iselin (B) Mid palmar space. (C) Thenar space (Byrne, J J.: Am J Surg. 88:439)

are to be avoided and the infection is to be drained in all its parts

The incision should be made along the side of the finger, extending the entire length of the tendon sheaths (Fig. 367, *left*). "The ends of the digital creases serve as land marks for the lateral plane of this incision."[5] Because of the extensive surgery necessary for adequate drainage of these infections, hospitalization is preferred.

In the postoperative care of these cases the important measures are immobilization by splinting in the semiflexed position, hot moist dressings of boric acid or saline and precaution against secondary infection.

The antibiotics, especially penicillin, have assumed a very important place in the treatment of acute tenosynovitis. Early in the course of the infection, massive doses may be employed in an effort to abort suppuration and necrosis A 24-hour trial of such therapy may be permitted. If the finger still shows signs of tenosynovitis at the end of this period, or if the patient was not seen until the tenosynovitis was of several days' duration, incision should be carried out without delay. Of course, the antibiotic therapy should be continued.

Infections of the Fascial Spaces of the Palm

Anatomy. To understand the infections of the fascial spaces of the palm, it is necessary to review its anatomy briefly (Fig. 367, *right*). The skin of the palm is closely attached by fibrous tissue septa to the underlying palmar fascia Between these septa lie collections of fat, which are most numerous at the distal part of the palm, just proximal to the bases of the fingers. Beneath the skin lies the fanlike extension of palmar fascia, which is most dense over the middle of the palm and sends projections to the proximal phalanx of each finger. From its deep surface there extends a fascial connection, which is attached along the length of the middle metacarpal bone.

This fascial attachment of the palmar fascia is important because it out-

lines the division between the major palmar spaces of the hand. Lying to the ulnar side of it are the flexor tendons of the middle, the ring and the fifth fingers, whereas the flexor tendons of the index finger lie to the thumb side. In this same plane with the tendons lie the vessels and the nerves of the hand. Between this layer of tendons and vessels and the interosseous muscles, which lie between the metacarpal bones on the ulnar side of the hand, is the middle palmar space. Mesially, this space is bounded by the fascial attachment of the palmaris longus along the middle metacarpal bone. Laterally, it extends to the hypothenar muscles; distally, to within a thumb's breadth of the base of the fingers, and, proximally, to the base of the palm.

Lying to the thumb side of the fascial attachment of the palmar fascia to the middle metacarpal bone is the thenar space; it is between the tendons and the anterior surface of the adductor pollicis muscle. This muscle also takes its origin along the middle metacarpal bone, and the space then lies between it and the fascial attachment to the bone and extends toward the thumb through the tissues of the web of the thumb. These are the major spaces of the palm, and they are of most significance from the surgical point of view.

Middle Palmar Space Infection

Etiology. The middle palmar space may become infected as the result of an extension of a tenosynovitis from the middle or the ring finger, in which case the infection invades the space by rupture of the proximal portion of the tendon sheath and extends along the lumbrical muscle to the palmar space. Infection of the tendon sheath of the fifth finger rarely produces an infection of the palmar space, since it extends along the tendon sheaths to the ulnar bursa. Infection of the space may result also from injuries to the palm, such as lacerations or compound fractures or from extension of collar button abscesses. Finally, in neglected cases, the pus may rupture from an infection of the thenar space through the fascial plate separating the two spaces.

Symptoms and Diagnosis. Usually, the symptoms of infection of the middle palmar space are quite typical; remembering the routes by which infection may travel to it, the history often is helpful in making the diagnosis. On inspection, the fingers, especially the middle and the ring fingers, are held in partial flexion, although, except in cases of an extension from a tenosynovitis, fixed flexion is not present. Swelling is characteristic; there is a loss of the cavity of the palm, especially on the ulnar side, with swelling most marked at the distal portion of the palm between the middle and the ring fingers. This area of swelling represents the extension along the lumbrical muscle to the loose connective tissues in the web of the fingers. There is always a very marked edema of the loose tissues of the dorsum of the hand. This edema is soft, it pits easily, and it is due to the fact that the lymphatic drainage is from the palm to the dorsum by the shortest possible route. This edematous swelling never should be incised with the mistaken idea that the purulent process lies on the dorsum. Finally, tenderness is acute on slight pressure over the outline of the middle palmar space.

Treatment. To drain an infection of the middle palmar space, an incision is made in the distal palm be-

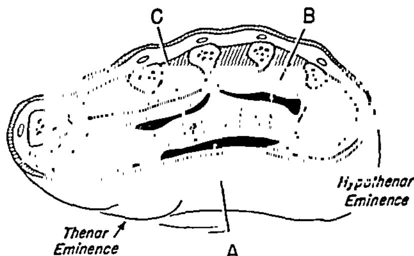


FIG. 367. Schematic cross section of palm of hand. (A) Pretendinous space of Iselin (B) Mid-palmar space. (C) Thenar space (Byrne, J J.: Am J. Surg. 88:139)

are to be avoided and the infection is to be drained in all its parts.

The incision should be made along the side of the finger, extending the entire length of the tendon sheaths (Fig. 367, *left*). "The ends of the digital creases serve as land marks for the lateral plane of this incision."[3] Because of the extensive surgery necessary for adequate drainage of these infections, hospitalization is preferred.

In the postoperative care of these cases the important measures are immobilization by splinting in the semiflexed position, hot moist dressings of boric acid or saline and precaution against secondary infection.

The antibiotics, especially penicillin, have assumed a very important place in the treatment of acute tenosynovitis. Early in the course of the infection, massive doses may be employed in an effort to abort suppuration and necrosis. A 24-hour trial of such therapy may be permitted. If the finger still shows signs of tenosynovitis at the end of this period, or if the patient was not seen until the tenosynovitis was of several days' duration, incision should be carried out without delay. Of course, the antibiotic therapy should be continued.

INFECTIONS OF THE FASCIAL SPACES OF THE PALM

Anatomy. To understand the infections of the fascial spaces of the palm, it is necessary to review its anatomy briefly (Fig. 367, *right*). The skin of the palm is closely attached by fibrous tissue septa to the underlying palmar fascia. Between these septa lie collections of fat, which are most numerous at the distal part of the palm, just proximal to the bases of the fingers. Beneath the skin lies the fanlike extension of palmar fascia, which is most dense over the middle of the palm and sends projections to the proximal phalanx of each finger. From its deep surface there extends a fascial connection, which is attached along the length of the middle metacarpal bone.

This fascial attachment of the palmar fascia is important because it out-

immobilization with a splint, intermittent application of hot solutions and elevation of the arm result usually in a rapid subsidence of the infection. The drain should be allowed to remain in place for only 3 or 4 days; thereafter, the splint is continued until purulent drainage ceases. Maintenance of elevation throughout the period of treatment reduces edema and permits earlier healing. The antibiotics, usually penicillin, are invaluable adjuncts to surgical treatment.

Hypothenar Space Infection

Anatomy. The hypothenar space is mentioned in the literature, but in reality there is no such fascial space comparable with the middle palmar and the thenar spaces. The name refers to the areas between the muscles of the hypothenar eminence. It is involved only by direct implantations of infection into these areas.

Treatment. Pus from this region does not tend to involve the other spaces of the hand or the tendon sheaths, and the treatment is simple incision and drainage over the prominence of the swelling at the site of the most exquisite tenderness. Drainage by the use of petrolatum gauze and splinting, elevation, antibiotics and hot wet dressings, as for other palmar infections, is recommended.

Infections of the Dorsum of the Hand

Subcutaneous Dorsal Space Infections

Anatomy and Etiology. There are two ill-defined fascial spaces on the dorsum of the hand (see Fig. 367, *right*). One is superficial and is called the subcutaneous space. It is composed of loose areolar tissue. Infection of this area arises most often by direct implantation, although frequently an abscess appears as a result of cellulitis or lymphangitis. In diagnosing this infection, it is noted that the swelling is more definitely an induration than the soft, pitting edema seen usually in infections of the palm.

Treatment. Simple incision and drainage are all that is necessary in treating a subcutaneous fascial infection. Splinting, hot wet dressings, elevation and antibiotics comprise the postoperative treatment.

Subaponeurotic Dorsal Space Infections

Anatomy and Etiology. The other space on the dorsum of the hand lies between the metacarpal bones and the aponeurotic plate, including the extensor tendons. Infection here is relatively rare, except from direct implantation from wounds over the dorsum of the hand. One of the common sites of infection from bite wounds following a blow on the knuckles is this space.

Symptoms. Symptoms of this infection usually are recognized easily, since the history of the injury and the appearance of the wound point definitely to a lesion on the dorsum of the hand. Swelling and edema of the dorsum are marked, but the absence of induration in the swelling, which is seen in subcutaneous infections, makes the diagnosis of subaponeurotic abscess more likely. Frequently it is *difficult to distinguish between these* infections, and often both spaces may be involved in wounds of the dorsum of the hand.

Treatment. Incision under general anesthesia with a tourniquet applied and followed by drainage, splinting, hot wet dressings and elevation usually produces rapid subsidence of the infection.

tween the middle and the ring fingers or between the ring and the fifth fingers. A curved hemostat, inserted with its point down, can be advanced over the head of the metacarpal bone into the middle palmar space, which can be drained easily by spreading the hemostat. *The incision is carried far* enough into the palm to permit adequate drainage, and a rubber dam or, better, petrolatum gauze is inserted into the opening.

The wound is dressed with voluminous gauze compresses, and the hand and the wrist are placed on a splint, the hand being padded so that the fingers are held in partial flexion.

In the postoperative care, elevation and hot wet dressings are the principal measures. The wound is dressed 2 or 3 days after incision, then at intervals of 2 days, the wound being irrigated with normal saline to remove slough. Usually, packing is not reinserted after the first or the second dressing.

Antibiotic therapy, usually penicillin in massive doses, is employed as an adjunct to surgical therapy, and occasionally bacitracin, 1,000 units per cc, is instilled into the space after drainage.

Thenar Space Infection

Etiology. The thenar space may be infected by an extension of an infection from the tendon sheath of the index finger. It occurs rarely from an infection of the tendon sheath of the thumb because this extends along the tendon sheath and involves the radial bursa. A collar-button type of abscess lying between *the middle and the index* fingers, if it is neglected, extends along the lumbrical canals and invades the thenar space. Finally, a direct implantation or a compound fracture may be the source of infection.

Symptoms and Diagnosis. The diagnosis may be made from the history if the knowledge of the sources of infection of this space are borne in mind. *On examination, the index* finger and, to lesser extent, the thumb are held in partial flexion, but they are not rigid unless there has been a previous tenosynovitis of the index finger. There is marked swelling of the radial side of the palm, as well as marked edema of the dorsum of the hand. The most characteristic observation is the ballooning out of the tissues of the web of the thumb, which appears to push the thumb as far away from the palm as possible. The swelling in the web is more marked perhaps on the dorsal than on the palmar side. Infection here extends along the palmar surface of the adductor pollicis and invades the loose areolar tissue of the thumb. Tenderness is marked over the area of the thenar space.

Treatment. Drainage of the thenar space is accomplished easily by incising the bulging tissues in the web of the thumb. The incision is made somewhat on the dorsum, a little to the thumb side of the first metacarpal bone and almost parallel to it. The operation is performed under general anesthesia with a blood-pressure tourniquet. As soon as the skin opening is made and any purulent material is sponged away, the extension of the infection may be seen passing anterior to the adductor pollicis into the thenar space. A petrolatum-gauze *drain inserted along the anterior sur*face of the adductor pollicis and underneath the tendon provides excellent drainage. Voluminous dressings,

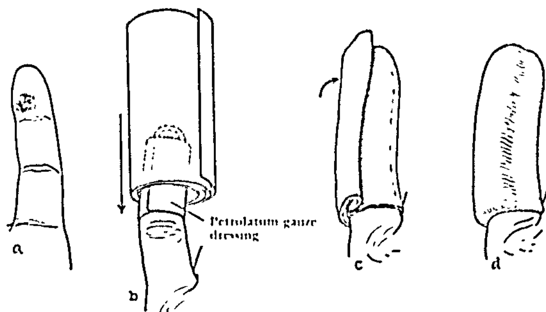


FIG. 368. Dressing for crush wounds (a) of the distal phalanx of the finger. After the wound has been cleansed thoroughly, it is protected with petrolatum gauze, and a cylinder of plaster is placed over the finger (b) This then is wet with sterile water and molded to form a plaster thimble (c & d), which is allowed to remain in place for about 3 weeks This dressing is borne easily and permits the patient to use the hand without pain from trauma to the finger.

and, finally, irrigation of the wound itself with sterile saline permit closure with a minimal danger of infection Devitalized tissues are cut away, but conservatism should be the rule in excising tissues of the finger If the patient can be seen within the first 12 hours after injury, tendons which are divided are sutured and the wounds are closed. The author has found that alloy steel wire is of particular value for such sutures, because it may remain in place for as long as 10 or 12 days without fear of reaction round it. As a rule, pressure dressings are sufficient to control hemorrhage from the wound. Splints made of hairpins enclosed in adhesive (Figs. 59, *left*, and 378, *right*) are of value in immobilizing the finger while healing takes place.

In wounds seen after the period of contamination, it is better not to attempt primary suture. The wound is cleansed as described above, its edges are pulled together with adhesive strips, and a splint is applied. If the wound becomes infected, it is opened and cared for easily, hot wet dressings being used. No attempt should be made to suture tendons if the wound is avulsed and crushed and cannot be débrided completely.

Crush Wounds of the Distal Phalanx

Etiology and Symptoms. Contusions of the distal phalanx with fracture of the phalanx and partial or complete avulsion of the nail are common, not only in industry but also in civil life, the fingertip being caught between objects or in house or automobile doors. The injury usually is quite characteristic: the proximal portion of the nail is ripped from its position under the eponychium and may lie on top of the eponychium, the entire base of the nail being exposed. A roentgenogram

Hand Infections in the Ambulatory Patient

The feeling is general among surgeons that hand infections are of such serious import that hospitalization should be the rule Therefore, the reader may question why these lesions should be mentioned in a work on surgery of the ambulatory patient. It is the author's experience that practically all paronychias, distal closed space infections, furuncles of the dorsum of a phalanx, infections of the dorsal surface of the hand and collar-button abscesses may well be treated in ambulatory patients The important requisite is that adequate operating facilities be available, including appropriate anesthesia. Home nursing care is necessary, but usually it can be provided, and the patients can go to the hospital or the surgeon's office for dressings and antibiotic therapy. Infections of the tendon sheaths of the fingers, middle palmar and thenar space abscesses, are less well treated in ambulatory patients, although the author has cared for these lesions in patients who were able to go to the hospital for incision and for subsequent dressings Infections of the tendons of the thumb and the fifth finger, because of their early involvement of the radial and the ulnar bursae, and infections of these bursae which involve the wrist and the forearm, are not amenable to ambulatory care. For this reason, no discussion of the treatment of extension of infections into the forearm is included here.

TRAUMATIC LESIONS

Wounds

The Fingers

Wounds of the fingers vary from simple cuts or punctures that involve only the skin and the subcutaneous tissues to extensive lacerations that involve the underlying tendons, bones and joints. Frequently they lead to minor or serious infections, and their prophylactic care should be a matter of serious consideration.

Treatment. Tiny puncture wounds, such as needle punctures, pinpricks and so forth, are not followed often by serious difficulties. Nevertheless, the question arises as to the best method of prophylaxis in such cases, since finger infections do follow these injuries occasionally. If the pinprick or the needle puncture occurs at the operating table, it is often wise to remove the glove and make a small incision at the site of the opening. By pressing upon the finger the opening is recognized by the appearance of a drop of blood. After a small incision is made with the point of a knife and the blood is sponged away, pure phenol may be inserted, or a simple wash with soap and water may be sufficient. If the injury occurred several hours or days before, it is wiser to await developments.

A larger potentially infected wound is treated as is any open traumatic wound elsewhere in the body (p. 153). If it can be seen and taken care of within 6 hours after injury, it is treated as a simple contaminated wound. With the use of the antibiotics prophylactically, the period of contamination may be prolonged to 24 hours. In the first-aid treatment, it is unwise to apply irritating antiseptics The wound should be covered with sterile gauze dressings and the patient transported to a dispensary or hospital, where appropriate first aid can be given.

Thorough cleansing of the surrounding tissues with soap and water

Patients usually seek treatment with the story that the finger was struck by a hammer, following which there was marked swelling and pain. On examination, there may be only an area of dark, bluish discoloration at the base *of the nail or, in more severe cases,* marked swelling with distention of the eponychium.

Treatment. *Rapid relief of pain is* obtained by permitting the escape of the blood. Early accomplishment of this *is* best, *when the blood still is* fluid. In those cases in which the eponychium is distended, the knife *edge may be inserted between the* eponychium and the nail, which permits blood to escape and relieves *tension. When the hematoma lies entirely* under the nail, it is necessary to make a small opening in the base of the *nail to permit the escape of the blood.* This is a somewhat painful procedure if much pressure is placed on the nail, *because such pressure increases tension* and, consequently, pain. If, however, an incision is made with the scalpel, *cutting more or* less across the nail without much pressure, little pain is experienced, and blood escapes in a large drop as soon as the nail is punctured. As a rule, a bit of the nail can be cut out by making two oblique incisions across its base. This permits continued drainage of blood and serum, and it prevents subsequent tension. A small pressure dressing of gauze overlaid by adhesive is all that is necessary.

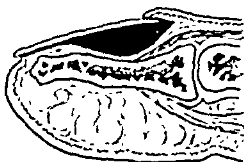


Fig. 369 Diagram of subungual hematoma Note the location of the blood in an unyielding space bounded, above, by the nail and, below, by the dorsum of the phalanx. This accounts for the excruciating pain from this relatively minor injury.

Water Faucet Injury

Anatomy and Etiology. The breaking of porcelain water faucets has become the frequent cause of injuries to the tendons of the palm. The breaking of the handle while force is being ap*plied produces a deep laceration that* not infrequently involves the under*lying tendons and sometimes the* nerves. The tendon most often involved is the flexor pollicis longus, and *the site of the injury usually is* along the inner border of the thenar eminence.

In the case of this injury, it is important at the first examination to recognize the possibility of tendon *and nerve injury, because adequate* and appropriate therapy then may be given with excellent results. Delayed *treatment leads to a more difficult op*eration and a less successful result.

If loss of flexion of the thumb indicates deep tendon injury, *the wound* should be protected with sterile gauze and the patient hospitalized for tendon suture.

Tendon Injuries and Tendon Suture

Injuries to the hand and the fingers, especially those producing cuts of the skin, are prone to divide the underlying tendons. The wound itself may be insignificant, a small cut with a knife or a piece of glass, but examination always should be made at the first inspection for evidence of a ten-

usually shows a fracture of the distal phalanx. If the crush has involved the palmar surface of the tip, there is a contused jagged wound.

Treatment. The *treatment of such an injury usually is simple and successful if it can be accomplished within a few hours of its occurrence.* The area is cleansed thoroughly with soap and water. The avulsed nail is cut away, usually without anesthesia, and the wound is covered with a layer or two *of sterile petrolatum gauze.* The entire dressing then is enclosed in a plaster thimble made with 4 or 5 layers of plaster rolled into a cylinder, put on the finger and then moistened with sterile water. The plaster is molded to conform to the shape of the finger and the fingertip, and is permitted to harden (Fig. 368). If this dressing is applied properly, it need not be changed until it is removed in about 10 days to 2 weeks. By this time, the wound usually has healed. When there is a fracture, it is wise to maintain the dressing for a longer period by the reapplication of a plaster thimble. By this method of therapy, pain is relieved, and the protection offered by the plaster thimble permits the use of the finger.

The Hand and the Fingers

Wounds of the hand and the fingers are extremely common in industry. *They are very important because even* small wounds may produce serious disability if they are complicated by tendon, nerve or bone injury or by tissue necrosis or infection. In such injuries, the patient almost always is ambulatory, and he may be seen for the first treatment in an office or a plant dispensary. The patient's best interests will be served if the wound is covered as soon as possible with a sterile dressing, if exploration of the wound is avoided, if antiseptic applications are withheld and if simple cleansing with soap and water round the covered *wound is the only first-aid treatment.*

It is most important to evaluate the wound for deep injury (tendon, nerve). Wounds involving only skin and subcutaneous tissue may be treated in an office or a dispensary with proper facilities. In the case of more serious injuries involving loss *of skin, open fractures, tendon and* nerve injuries, the patient should be hospitalized to obtain the benefit of adequate anesthesia, instruments, assistance, light, etc.

Mason[23] has outlined the important steps in the treatment of hand wounds. He emphasizes the importance of preserving all viable tissue, obtaining hemostasis and effecting primary closure of the wound, if necessary by skin graft. The hand should be dressed with a compression dressing and splinted in the position of function (slight dorsiflexion of the wrist with fingers in partial flexion). Antibiotics are given *prophylactically* as a rule.

For skin suture, it is our choice to use fine alloy steel wire. The lack of reaction in the tissues makes it possible to leave these sutures in place for as long as 2 or 3 weeks.

Subungual Hematoma

Etiology and Symptoms. Blows on the fingernail produce a hemorrhage under the nail. Although relatively minor, this injury causes excruciating pain because there is marked tension in the unyielding space bounded by the firm nail above and the bone below (Fig. 369). Most carpenters know better than most physicians that relief of tension in this area will permit relief of pain.

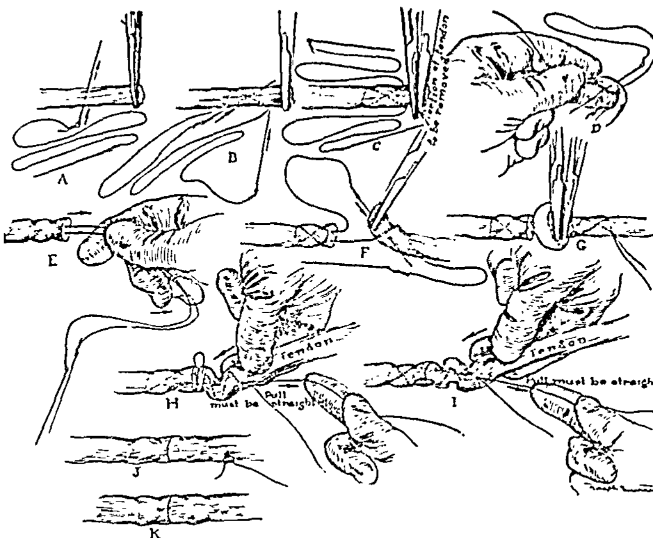


Fig. 372. Suture of tendons with silk technic. (A-D) With a thread and 2 needles, the sutures are placed to traverse the tendon with each needle from 2 to 4 times and emerge through the end (E) All slack is drawn out (F-G) In the same way, the suture is continued up the other tendon Both ends are brought out at the same spot. To prevent spearing the thread, the 2 needles should be thrust through the tendon at the same time (H-I) To prevent the tendon ends from separating under strain, the slack is removed from the second tendon. To do this, 1 suture is pulled at a time as the tendon is shoved along it to snug against the other tendon end. (J-K) There is only 1 knot; when tied, it sinks into the tendon, and at a place at which it receives the least strain, as knots are the weakest parts of a tendon suture (Bunnell, Sterling: Surgery of the Hand, Philadelphia, Lippincott)

to be enlarged, or a second incision may be necessary to locate a retracted tendon. Such incisions should be made in flexion creases and along the sides of the fingers to avoid scar contracture and adhesions.

In preparing the tendon for suture, the traumatized end is excised conservatively; in clean cuts, no excision at all may be necessary. When the flexor tendons of the finger are divided, it is best usually to sacrifice the sublimus tendon, from its attachment to the base of the middle phalanx to

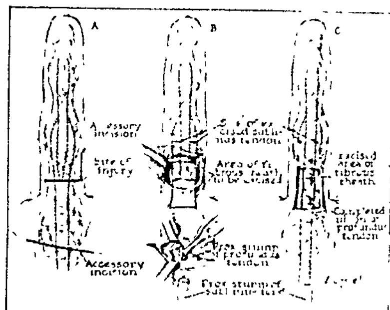


FIG. 370 Method of repair of flexor tendons of the finger. With division of both flexor tendons in the finger, the profundus tendon only should be sutured. The original wound is enlarged to permit excision of the distal sublimis stumps and to allow sufficient room for tendon suture The proximal stump of the profundus is picked up through an accessory incision in the palm and led back through the tunnel into the finger, and repair is accomplished A square segment about 1 cm. long then is excised from the fibrous sheath over the site of tendon repair When the skin is closed, this square window is covered by the subcutaneous fat, which will permit gliding of the tendon after healing. (Mason, Michael L. Surg, Gynec & Obst. 70:392)

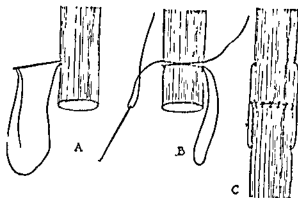


FIG. 371. Technic of end-to-end tendon suture. (Koch, Sumner L. Surg., Gynec. & Obst. 78:17)

don injury. When a tendon division is demonstrated, suture should not be attempted without adequate facilities, which usually are to be found only in a hospital operating room. However, the patient may be ambulatory with a splint after operation.

Mason[23] believes that, to be successful, a primary suture of a divided tendon should be performed within 2 hours after injury, and only after very careful preparation of the wound, which consists of excision of nonviable tissue after meticulous skin cleansing and wound lavage. It is probable that by using the antibiotics, this time limit may be lengthened. A bloodless field produced by an inflated blood-pressure cuff acting as a tourniquet makes rapid and careful work possible. In a bloodless wound irrigated frequently with saline, nonviable tissue is excised with forceps and a knife, but wide wound excision usually is not performed. Often, in small wounds of the fingers and the hands made by sharp objects, such as a chisel or a piece of glass, no tissue need be sacrificed. Tendons, nerves and blood vessels must be protected carefully.

In obtaining exposure of the severed tendons, the incision may have

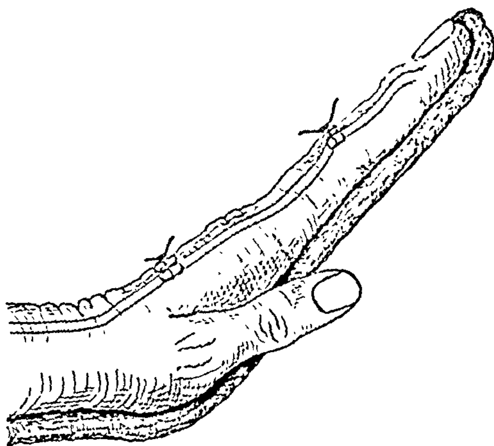


Fig. 374. For primary repair of extensor tendons, a simple figure-of-eight stitch with No. 35 stainless-steel wire is used. One loop unites the tendon ends and the other the skin edges. The stitch is without strength and is merely for approximation of tendon ends. Splinting, as shown, prevents the tendon ends from pulling apart. (Bunnell, Sterling: J. Bone & Joint Surg. 23:245)

with fine sutures in the fibrous tissue surrounding them.

After careful skin closure, a firm pressure dressing is applied before the tourniquet is removed, and the part is splinted in such a position as to produce maximum relaxation of the sutured tendon. Unless some complication appears, the wound should not be dressed for 2 weeks at least. Mason and Allen[20] have shown that tendons heal better if complete immobilization is maintained for 14 days at least. During the third and the fourth weeks, restricted use of the tendon "may be expected to lead to only a slight increase in reaction and to a rapid increase in tensile strength of the union." Unguarded use may be permitted 4 to 5 weeks after tendon suture.

Contusions of the Dorsum of the Hand

Contusions of the dorsum of the hand are seen frequently, particularly in women and children whose hands have been caught in a clothes wringer. A rupture of some of the vessels of the dorsum produces rapid swelling and sometimes hematoma formation.

Treatment. If the patient is seen early, an excellent form of treatment is to apply a pressure bandage incorporating a fluff gauze or mechanic's

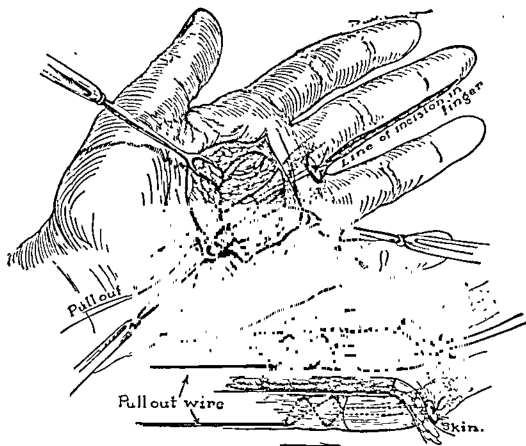


Fig 373 Suturing a tendon in palm by removable stainless-steel wire In 3 weeks the tendon will have joined, and, after being cut, the suture beneath the button may be withdrawn backward by the pull-out wire, which is looped about it (Bunnell, Sterling. Surgery of the Hand, Philadelphia, Lippincott)

a point well proximal to the point of division (see Fig. 370). The nerves should be identified, and, if any are severed, they should be prepared for suture in the same way as the tendons. After thorough preparation of the wound, the tourniquet is released temporarily while all bleeders are ligated with fine silk

Tendons should be sutured with material that produces the least reaction in the tissue and the least bulk at the suture line. Fine silk (Fig. 372) and fine alloy steel wire (Figs. 373 and 374) fit these requirements best. Mason and Allen[26] approximate the cut ends with transverse stay sutures of silk (see Fig 371), uniting the peritendinous tissues with fine interrupted sutures of the same material. Bunnell[3] uses alloy steel wire that may be removed with a pull-out wire when the tendon healing has occurred (3 weeks) (see Fig 373). When the tendons are divided in a tendon sheath, a segment of the sheath overlying the suture line should be excised, or the tendon sheath should be split its length along the lateral attachment to the phalanx.

When divided nerves are found in association with tendon injuries, they should be approximated carefully

to cover the tip of the finger, it is necessary to amputate part of the bone. This shortens the phalanx and increases the deformity.

In a few cases, the amputated bit of skin and soft tissues is at hand or is *hanging by a mere shred*. When this is so, the wound should be cleansed thoroughly with soap and water and the detached portion of the skin and the soft tissues sewn in place with fine silk or wire sutures. However, the amputated portion usually is not available for suture and, therefore, the defect may be covered with a graft removed from the forearm or the thigh. This should be cut accurately to fit the site. The edges of the graft should be free of any subcutaneous fat, but the middle of the graft often may contain a small amount of fatty tissue to advantage. The graft is sewn in place with fine silk sutures, and a dressing of paraffin gauze with a snug bandage and a hairpin splint is applied. Unless *there is some reason to suspect that* the graft is not taking or because of the presence of infection, it is wise not to change the dressings for a period of from 7 to 10 days. At this time, the sutures may be removed and protective dressings applied until firm healing takes place.

Kutler[21] has devised an ingenious plastic closure by advancing triangular flaps of adjacent skin to cover the fingertip (Fig. 375); Jones[15] and Fusco[7] use palmar flaps to cover the cutaneous defect (Fig. 376).

Traumatic Amputation of the Fingers

Transverse traumatic amputations of one or more fingers occur not infrequently in industrial accidents, due to saws or other machines.

Treatment. These wounds receive the same careful cleansing as do other traumatic wounds (p. 153). Then the problem arises as to the formation of a soft tissue closure of the amputated finger.

An incision usually is made on each side of the finger, and the soft tissues are reflected back from the exposed bone. The bone is cut away with rongeurs or bone-cutting forceps a distance of about ½ in. This permits closure of the soft tissues over the end of the bone, which produces a much more serviceable finger stump than when the wound is permitted to heal with the bone under the scar.

Practical Points in the Treatment of Injuries of the Fingers

Practically all injuries of the finger can be treated with a local anesthetic injected to block the nerves at the base of the finger or in the distal palm. In most cases, it is wise to inject the anesthetic before attempting *to cleanse the part*, thus the anesthesia begins to take effect while the area round the wound is being cleaned. By the time the wound itself is cleaned, the finger is insensitive to pain.

A blood-pressure cuff used as a tourniquet prevents bleeding during the care of the finger.

As a rule, it is not necessary in most of these injuries to ligate the vessels. Pressure bandages usually are sufficient to produce hemostasis (Fig. 377).

Foreign Bodies

Of the Fingertip

The fingertip is a common site of foreign bodies. These may be broken-off needles, bits of glass, splinters and so forth. In any event, the presence of a foreign body in the fingertip is not only a possible and likely source of infection but, if healing occurs

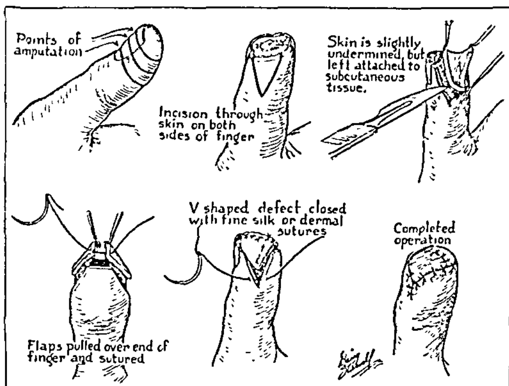


Fig. 375 Method of plastic closure of traumatic amputation of the fingertip. (Kutler, William: Ohio State M. J. 40:126)

waste and place the hand on a splint. *If there is a hematoma, in spite of the fact that fluctuation may be present, aspiration is of no value.* Incision and drainage permit evacuation of the clot with more rapid and complete subsidence of the swelling. In cases untreated for a long time, the fibrosis that results from prolonged edema of the dorsum of the hand may give discomfort and some disability. Little can be done in the way of therapy except to prevent edema by pressure and elevation The swelling and the discomfort disappear gradually, but it sometimes takes several weeks, even months, for complete subsidence of the process. In patients with persistent disability, some authors[22] have recommended excision of the hard mass of scar tissue. This never has been necessary in our experience.

Traumatic Amputation of the *Soft Tissues of the Distal Phalanx*

Knife, razor and glass injuries to the distal phalanx often result in the traumatic amputation of the soft tissues of the finger, and frequently the bone is exposed. In such cases, if healing is allowed to take place, the result is a scar deformity of the distal phalanx, which is tender and often produces *marked disability*. This is true especially if the tip of the bone lies directly under the scar.

Treatment. A very valuable procedure is to cover this area immediately with a full-thickness graft, as described by Reed and Harcourt.[31] Not only does this shorten the period of recovery, but more particularly it prevents the deformity that otherwise would occur. In many of these patients, the soft tissues are gone, and,

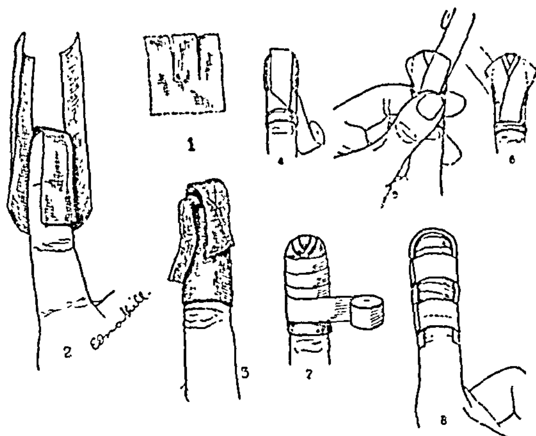


FIG. 377. Steps in the application of a bandage to the fingertip.

without infection, it is a cause of discomfort to the patient. For this reason, a foreign body is removed as soon as possible.

Treatment. This operation is performed under local anesthesia with a tourniquet applied at the base of the finger. The wound made in removing the foreign body is cleansed thoroughly, and primary sutures usually are employed.

Under the Fingernail

Splinters of glass, bits of steel wool and especially wood splinters are bodies found frequently under the fingernail. They cause considerable discomfort, and they are not without some danger as a source of infection. Most patients seek treatment after they themselves have attempted to remove the foreign body with a needle or a knife tip. As a rule, the foreign body is cut off or broken off well below the juncture of the soft tissues with the nail.

Treatment. The treatment consists of incising a wedge-shaped area of the nail over the foreign body (see Fig. 95). This usually can be performed with a scalpel without anesthesia, although some discomfort is associated with the procedure. It is wise to make the point of the wedge at the farthest extent of the foreign body under the nail. In this way, the wound is laid wide open, and the danger from subsequent infection is relatively slight. After removing the overlying portion of nail, the resulting wound may be treated for a few minutes with a pledget of 2 per cent procaine hydrochloride, then cleaned with soap and water and a simple dressing applied. Infection

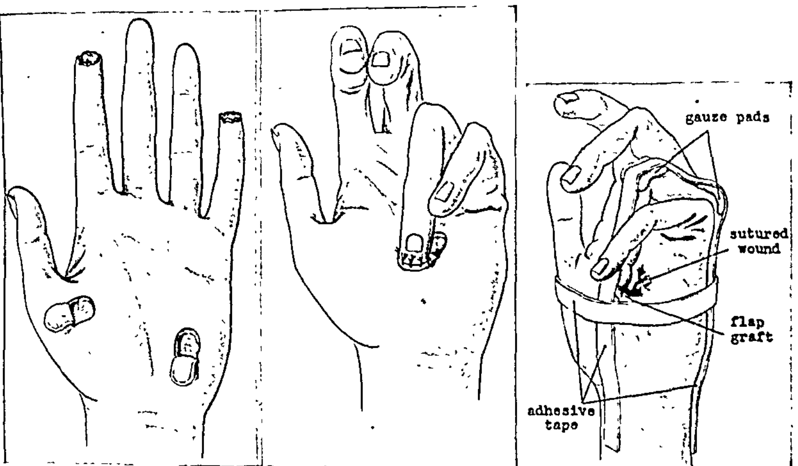


Fig. 376 (*Left*) Lateral and proximal types of pedicle flaps. (*Center*) Method of suturing flaps to defect on fingertips. Kinking of flaps should be avoided. (*Right*) Completed operation. The wound in the palm has been sutured after uniting the flap to the fingertip. (The author has also covered the palmar defect with a free graft in several cases.) An adhesive support is applied before bandaging. (Jones, Robert A.: Am. J. Surg. 55:331)

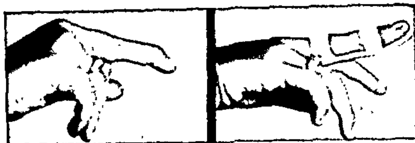


FIG. 378 (*Left*) Recent mallet finger. Note the inability to extend completely the distal phalanx and the swelling in the region of the distal interphalangeal joint. (*Right*) Hairpin splint used to hold the distal phalanx in extension. This is an excellent temporary splint, but it is not as valuable as the plaster thimble (Fig. 379) in treating mallet finger.

evidence of fracture, the tendon tear occurs from a force applied not directly end on, but slightly on the dorsum, and the tendon rupture occurs not at the distal interphalangeal joint but in the extensor tendon over the middle phalanx. On examination, he finds definite acute pain and tenderness in this area. In children, the same trauma may result in an epiphyseal separation of the distal phalanx. The extensor tendon, being inserted on the epiphysis, the diaphysis of the bone is displaced forward, and the deformity that results is practically the same as that noted in mallet finger.

A large majority of these injuries go without adequate treatment, and, as a result, there is a gradual subsidence of the swelling and the pain in the region of the distal interphalangeal joint, but the thickening of the joint and the inability to flex the distal phalanx remain as a disfiguring and somewhat disabling deformity (Fig. 378, *left*; see also Fig 381B).

Treatment. Successful treatment of mallet finger depends on the early recognition of the lesion and the early institution of appropriate therapy. A roentgen examination is a wise precaution to ascertain if there is a fracture of the base of the distal phalanx and, if there is, to determine its type. In those cases without fracture, the supposition is that the disability is due to a tear of the extensor tendon, and an examination should show whether the lesion is at the distal interphalangeal joint, which is commonly the case, or over the middle phalanx, as suggested by Kaplan.

Treatment may be conservative or operative. Conservative treatment consists of immobilizing the finger, especially the distal interphalangeal joint, in hyperextension. This may be done by splinting (Fig. 378, *right*) or, more successfully, by applying a plaster cast, as suggested by Smillie.[33] A cylinder of plaster bandage is rolled 4 or 5 layers thick and applied over the involved finger, which then is dipped into water, and the plaster is molded firmly to the finger. The patient himself holds the distal phalanx in hyperextension and the proximal interphalangeal joint in flexion by pressing the finger involved against the thumb (Fig. 379). In this way, the extensor tendon is relaxed, and thus the distal phalanx is held in the position in which healing of the ruptured tendon is most likely to occur. This dressing

rarely occurs in wounds so treated, although the finger must be protected until the nail grows in again. A small piece of adhesive usually is sufficient for protection.

Of the Hand

Treatment. The hand is a frequent site of foreign bodies of many sorts. Sharp-pointed bodies, such as needles, should be localized accurately (p. 168). A blood-pressure cuff used as a tourniquet is necessary in removing foreign bodies. Usually, after a needle is located, it can be removed under local anesthesia without opening the entire extent of the wound in which it is implanted, and primary suture is permitted.

When the invader is a splinter or a cinder, possibly carrying foreign material and bacteria into the tissues, it is wiser to open the entire extent of the wound, unless this necessitates cutting tendons and other important structures. Such a wound may be sutured loosely, but it should be observed closely for evidences of infection.

The antibiotics, usually penicillin, are given as a prophylactic measure. Tetanus antitoxin or toxoid is given as a routine procedure, except when the foreign body is a needle.

Tendon Injuries

Mallet Finger (Baseball Finger, Drop Finger)

Etiology. Mallet finger and drop finger are names given commonly to the deformity of the distal phalanx that results when the extended finger is struck end on. A forcible flexion of the distal phalanx on the middle phalanx occurs. This accident occurs often in sports, where a baseball or a football is caught on the end of the finger. In ordinary life, it is seen when a patient strikes an open door in the dark with the finger extended or receives a similar blow. Occasionally it occurs when a patient catches the finger or the fingernail in some firm object, as the seam of a stocking, while the fingers and the wrist are extended. Roemer[32] presents good evidence that hyperextension of the distal joint may produce the disability.

Symptoms. In some cases, the injury is so trivial that it is disregarded. On the other hand, the patient may feel or hear a snap and experience sharp pain in the region of the distal interphalangeal joint. As a rule, swelling occurs in the joint region, and there is some soreness, but the chief symptom is an inability to extend the distal phalanx. Swelling and tenderness sometimes mask this important symptom, and the true disability is disregarded in the early phases of treatment.

The trauma producing mallet finger may result in several different kinds of injury, the most frequent of which is probably a tear of the extensor tendon at its insertion on the base of the distal phalanx. In some cases, there may be an associated sprain fracture with a tearing away of bone at the insertion of the extensor tendon. Kaplan[18] is of the opinion that end-on trauma to the extended finger produces not a tear of the tendon but a triangular fracture of the base of the distal phalanx on its dorsal surface. This interrupts the balance between the extensors and the flexors of the finger, and, because of a partial destruction of the articular surface of the distal phalanx, the result is a preponderance of flexor action, with the resulting mallet finger. He believes that, when there is no roentgen-ray

lanx, the prognosis is not very good, and frequently little improvement can be obtained by operation because of the bony deformity in the joint.

Buttonhole Rupture of the Extensor Tendon Over the Proximal Interphalangeal Joint

Anatomy. Another less common tendon rupture of the finger is that of the aponeurosis of the extensor tendon over the proximal interphalangeal joint. To understand this injury, it is necessary to be conversant with the anatomy of the extensor tendon in this area. In approaching the metacarpophalangeal joint, the extensor tendon spreads fanlike over the proximal phalanx and separates into two lateral bands and one central band. The central band inserts at the base of the middle phalanx and has to do with the extension of that phalanx on the proximal phalanx The lateral bands have the tendinous insertions of the interosseous muscles attached to them. They extend lateral to the proximal interphalangeal joint and thence unite over the middle phalanx to insert at the base of the distal phalanx (Fig. 380).

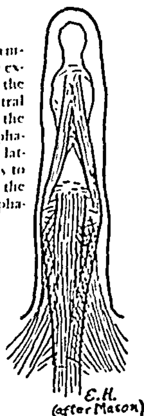


Fig. 380. Diagrammatic drawing of the extensor tendon of the finger. Note the central slip, which inserts at the base of the middle phalanx, and the two lateral slips, which pass to join and insert at the base of the distal phalanx.

Etiology. The injury causes a tear of the central band of the extensor tendon (Fig. 381). It may occur indirectly as the result of a forceful flexion of the distal and the middle phalanges on the proximal phalanx while the finger is being held in extension. Thus, in sports, the finger often is struck on the back of the middle phalanx while it is being held in extension. The injury often occurs directly from a blow over the proximal interphalangeal joint, the tendon being sheared off by the traumatizing force acting against the head of the proximal phalanx.

Symptoms. The finger becomes swollen and painful. On examination, there is an inability to extend the middle upon the proximal phalanx, with the finger thus held in partial flexion. Efforts to extend it result in a hyperextension of the distal phalanx and an extension of the proximal phalanx, the middle phalanx remaining in flexion (Fig 382). In chronic cases, the patient learns that he can extend the finger passively with the other hand more easily if he does not contract the extensors actively. This disability results from the fact that the tear of the central slip of the extensor tendon, which normally inserts at the base of the middle phalanx, permits the head of the proximal phalanx to extend upward through a buttonhole-like opening with flexion of the finger. When efforts are made to extend the finger, the lateral slips of the extensor tendon going to the distal phalanx



Fig. 379. Plaster thimble for treatment of mallet finger. Three or four layers of 3-in plaster bandage are rolled into a cylinder; this is slipped over the finger, and the finger is dipped in a vessel of water. While the plaster is wet, it is molded to the finger while the distal phalanx is held in hyperextension and the proximal phalanx is held in flexion by the patient; this relaxes the extensor tendon to the distal phalanx.

is allowed to remain in place for 5 weeks at least. There is no difficulty from pressure in such a dressing, and most patients are able to pursue their usual occupation with the cast in place

We have used the same method of therapy in many cases in which there was a triangular fracture at the base of the distal phalanx. If postreduction roentgenograms show the fragments to be in good position, nothing further is necessary to obtain good union and a good result.

Operative therapy is recommended as the treatment of choice by Mason,[24] Kaplan[18] and others. Mason believes *that, in cases of complete rupture,* fragments of the torn tendon may fall into the joint space, preventing normal healing of the tendon and producing disability in extension of the joint. Kaplan feels that a replacement of the fractured fragment at the base of the distal phalanx is necessary to obtain a normal articular surface and a good result in cases in which a definite fracture is demonstrated.

Certainly, in all cases of old injury, little can be expected from conservative treatment, and operation is the only method of improving the result. This may be performed with a local block anesthesia at the base of the finger. A U- or an L-shaped flap is made, the flap being turned away from the distal phalanx, as recommended by Mason[24] and Smillie,[33] or toward the distal phalanx, as recommended by Kaplan.[18] Through either incision, the extensor tendon is exposed. The site of the tear in the tendon can be recognized easily, and the two ends are approximated with fine silk sutures mounted on a small curved cutting-edge needle. In old cases, the area of the tear often is united by scar tissue, which must be excised, and the tendon ends must be approximated if normal extension of the distal phalanx is to be obtained. *After suture of the wound, sterile* petrolatum gauze is placed over it, and the wound is encased in a plaster cylinder (Fig. 379). This dressing is allowed to remain in place for from 4 to 5 weeks. If the skin sutures are of fine alloy steel wire, they may be left in place for this length of time without difficulty.

The prognosis for a complete resumption of extension in the injured phalanx is good if early treatment is instituted. A good functional result may be obtained likewise in old cases if tendon rupture is the cause of the disability. However, in old cases of fracture of the base of the distal pha-

often the rupture occurs some time after a fracture of the lower radius. The cause of the rupture probably is an interference with the blood supply of the tendon, with a resulting gradual aseptic necrosis of the tendon fibers. The long and rather oblique course of the tendon across the dorsum of the wrist and the firm fixation of the tendon in the dense osseoligamentous tunnel are factors that are suggested as the causes of the gradual fraying and the eventual rupture of the tendon. The injury occurs more frequently in males than in females, and in about 80 per cent of the cases it is the right thumb that is involved. The rupture always occurs at the distal end of the dorsocarpal ligament.

Symptoms. The patient gives a history of a sudden, usually painless, loss of function of the thumb. Mason[24] states that only slight swelling appears, but that the functional loss is quite typical. The prominent dorsal border of the anatomic snuffbox is lost. The distal phalanx of the thumb is flexed and cannot be extended unless the thumb is adducted.

Treatment. The only method of therapy is surgical Operation may be performed under local anesthesia, but the frayed ends of the tendon rarely can be approximated. In some instances, the stumps may be sutured to an adjacent tendon. When these have united, a second operation is performed, and a longitudinal strip of the host tendon is excised to fill in the gap between the tendon ends. Mason suggests as the best method of therapy a tendon transplant from one of the dorsal tendons of the foot. Other authors believe that early operation may permit immediate suture of the ends of the tendon.

After any of these tendon repairs, the thumb must be supported in complete extension for at least 3 weeks, followed by a guarded resumption of function.

Traumatic Tenosynovitis (Peritendinitis Crepitans)

Etiology. So called traumatic tenosynovitis is an affection seen frequently by industrial surgeons and less often in private and dispensary practice. The usual history is that the patient, after a more or less sedentary life, indulges in prolonged or strenuous muscular exertion. Thus we have seen this lesion appear in a college professor who played five sets of tennis on an indoor court in one day during the winter. It may appear in those who step up their normal activity. Thus we saw 3 cases of traumatic tenosynovitis in wrappers of gum who, in order to increase wages, had raced each other to see who could wrap the most packages of gum. Finally, the condition occurs in those carrying out their normal work following trauma.

Pathology. Howard[11] has demonstrated the pathology of the affection by incision and pathologic specimens. He found a jellylike edema of the areolar tissue about the musculotendinous junction, thrombosis of the veins and an interstitial fibrous deposit. The muscle is shown to have lost its glycogen, and there is even muscle-fiber destruction. Howard believes that the condition arises from fatigue and an exhaustion of a definite muscle group. He points out that, in reality, the condition is not a tenosynovitis, because the portion of the tendon having a synovial sheath is unaffected. He believes that the primary change is in the muscle.

Symptoms. The symptoms are quite typical. There is a localized swelling,

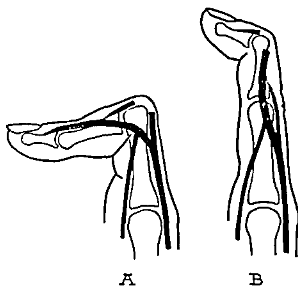


FIG. 381. Diagrammatic representation of ruptures of the extensor tendon of the finger. (A) Rupture of the central slip, which inserts at the base of the middle phalanx; this is commonly called a buttonhole rupture. On flexion, the head of the proximal phalanx passes between the lateral slips of the extensor tendon and is caught there when attempts are made to extend the finger. (B) Diagrammatic representation of mallet finger, that is, rupture of the extensor tendon inserting on the base of the distal phalanx.



FIG. 382. Buttonhole rupture of the extensor tendon The patient is attempting to extend the finger. Note the hyperextension of the distal phalanx, the middle interphalangeal joint remaining in flexion. The prominence of the head of the proximal phalanx may be noted.

prevent extension by tightening round the head of the proximal phalanx. The harder the patient tries to extend the finger, the more tightly is the head held between the lateral slips of the tendon.

Treatment. Usually this injury responds well to operative repair of the ruptured tendon An L- or a U-shaped incision is made over the proximal interphalangeal joint. The tear in the tendon exposes the joint, and, with flexion of the finger, the head of the proximal phalanx presents in the wound. With the finger held in extension, the ruptured tendon is sutured in place with fine silk sutures, a very small cutting-edge needle being used. It is well to approximate the lateral slips of the tendon with sutures proximal to the joint. The skin wound is closed with fine silk sutures, and the finger is fixed in full extension in light plaster for 3 weeks. The operation may be performed under local anesthesia.

The prognosis for complete recovery of function is good. The earlier the operation is performed, the better the final result.

Rupture of the Extensor Pollicis Longus Tendon (Drummers' Palsy)

Etiology. Rupture of the long extensor tendon to the thumb is a relatively uncommon lesion. It is frequently spoken of as a spontaneous rupture, although the probability is that usually a long-continued trauma, as in some industries, or occasionally a single trauma may be a factor. Most

pulled back through the stenosed portion of the sheath.

Etiology. Trigger finger is a disability seen occasionally in childhood. It is due to a congenital inequality between the tendon sheaths and the tendons. The lesion is more common in adult life, and, as a rule, it follows a trauma in the region of the metacarpophalangeal joint. The flexor tendon of the thumb is involved more often than the flexor tendons of the other fingers.

Treatment. Treatment of this lesion by surgery is very simple. By palpation, one feels the enlarged portion of the tendon where it slips through the stenosed area of the tendon sheath. Under local infiltration anesthesia, with hemostasis controlled by a tourniquet, an incision is made over the bulbous area of the tendon. The patient can flex and extend the finger under local anesthesia, and the pathology may be visualized. Incision of the stenosed area of the tendon sheath permits the enlarged area of tendon to move without obstruction. In a few cases, the enlarged area of tendon is excised to make it of uniform size, but usually this is not necessary. After closing the wound, a simple pressure dressing is applied without splinting. The patient is encouraged to use the finger from the very first to prevent adhesions between the tendon sheath and the tendon. A cure results as soon as the tendon sheath is incised.

Compound F (Hydrocortone) has been used locally to produce a local inhibition of inflammatory reaction, and this has been tried in the treatment of trigger finger. Several authors[10,12] have injected from 0.1 to 0.5 cc. (25 mg. per cc.) into the tendon and the sheath involved and report relief of pain and disappearance of trigger symptom. From 1 to 3 weekly injections were given. This method of therapy has not had a wide clinical trial, but it appears to warrant such a trial. If it fails, operation can be performed.

STENOSING TENOVAGINITIS AT THE RADIAL STYLOID

(De Quervain's Disease)

Pathology. De Quervain first described this lesion as a narrowing of that part of the tendon sheath lying over the styloid process of the radius through which pass the tendon of the extensor pollicis brevis and the abductor pollicis longus. The pathologic change consists of a serous effusion within the sheath of the tendon, with edema and a marked thickening of the dense fibrous layer of the tendon sheath. The thickening leads to a constriction that may be almost cartilaginous in consistency. At the same time, there may be a fusiform enlargement of the tendon beyond the point of constriction.

Etiology. The disease usually is due to some form of trauma, more often chronic than acute, although in many cases it has followed some single acute injury. Most often, activities that require ulnar deviation of the hand and the wrist with the thumb fixed on some object are found to produce this lesion. It is seen much more commonly in women than in men and seems to follow sewing, typewriting, knitting, golfing and piano playing.

Symptoms. The usual complaint is pain about the styloid of the radius that radiates up the forearm and into the thumb. Swelling may or may not be present. On examination, there is definite tenderness over the styloid of the radius, and, if the patient's thumb is grasped and the hand is abducted

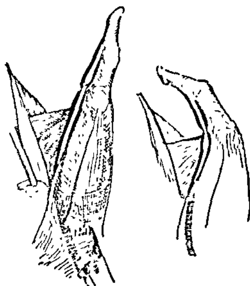


FIG. 383. Diagrammatic view of a trigger finger, showing the fusiform swelling of the flexor tendon in the region of the metacarpal joint. When this swelling clicks through the narrowed portion of the tendon sheath, the finger suddenly comes into extension. Incision of the tendon sheath is all that is necessary to effect a cure.

usually on the dorsum of the forearm and the wrist. There are often edema, slight hyperemia and pain on movement of the involved muscles, usually the extensors of the wrist or of the fingers or the thumb. The characteristic symptom on which the diagnosis may be based is a definite crepitus along the wrist and the lower forearm when the muscles and the tendons involved are used. With a stethoscope placed over the tendon involved, a definite crunching and even squeaking, such as that obtained by twisting leather, may be heard. The crepitus often is described as the sensation obtained by crunching snow in the hand.

Treatment. The treatment of crepitating peritendinitis is rest of the muscle groups involved. In the wrist, this usually signifies rest not only of the wrist but also of the fingers. This is accomplished best by a light plaster or other type of molded splint, which includes the thumb. Howard[11] reports an average disability of 11.6 days in patients treated by complete immobilization, and the author has confirmed this observation in many cases. As a rule, baking, massage and pressure dressings do not effect a cure.

TENOSYNOVITIS STENOSANS

(Trigger Finger or Snapping Finger)

These names are given to a finger disability in which the patient notices a snapping or a jerking sensation over the area of a tendon of a single finger as it is flexed or extended actively or passively.

Pathology. An understanding of the pathology is necessary to obtain a clear-cut picture of the symptoms. There is a fusiform thickening of the flexor tendon in the region of the metacarpophalangeal joint (Fig. 383). The sheath of the tendon in this area is not elastic. Constant irritation to both the tendon and the tendon sheath, due to the passage of the fusiform swelling of the tendon through the inelastic sheath, produces an actual thickening of the sheath with gradual constriction and narrowing of its lumen. This produces a more marked irritation of the tendon itself with an increased thickening. As the finger is extended and the tendon passes through the narrowed area, more and more force must be employed to pull the enlarged area of tendon through the constricted portion of the sheath. When this is accomplished finally, the finger snaps into extension. The reverse of this procedure occurs when the finger is flexed, and the fusiform swelling must be

pulled back through the stenosed portion of the sheath.

Etiology. Trigger finger is a disability seen occasionally in childhood. It is due to a congenital inequality between the tendon sheaths and the tendons. The lesion is more common in adult life, and, as a rule, it follows a trauma in the region of the metacarpophalangeal joint. The flexor tendon of the thumb is involved more often than the flexor tendons of the other fingers.

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STENOSING TENOVAGINITIS AT THE RADIAL STYLOID

(De Quervain's Disease)

Pathology. De Quervain first described this lesion as a narrowing of that part of the tendon sheath lying over the styloid process of the radius through which pass the tendon of the extensor pollicis brevis and the abductor pollicis longus. The pathologic change consists of a serous effusion within the sheath of the tendon, with edema and a marked thickening of the dense fibrous layer of the tendon sheath. The thickening leads to a constriction that may be almost cartilaginous in consistency. At the same time, there may be a fusiform enlargement of the tendon beyond the point of constriction.

Etiology. The disease usually is due to some form of trauma, more often chronic than acute, although in many cases it has followed some single acute injury. Most often, activities that require ulnar deviation of the hand and the wrist with the thumb fixed on some object are found to produce this lesion. It is seen much more commonly in women than in men and seems to follow sewing, typewriting, knitting, golfing and piano playing.

Symptoms. The usual complaint is pain about the styloid of the radius that radiates up the forearm and into the thumb. Swelling may or may not be present. On examination, there is definite tenderness over the styloid of the radius, and, if the patient's thumb is grasped and the hand is abducted

quickly toward the ulna, pain over the tip of the styloid is marked. In most cases, on deep palpation there is a thickening, if not a hard mass, in the region of the radial styloid.

Treatment. Immobilization usually results in a cure in a period of 5 to 6 weeks, but a much more satisfactory and rapid cure results from operation under local anesthesia. With a tourniquet controlling bleeding, an incision is made over the radial styloid to expose the sheath overlying the extensor pollicis brevis and the abductor pollicis longus. The hard, thickened sheath is incised, and frequently a portion of it is excised. The wound is closed loosely, and a dressing is applied with moderate pressure. No splint is required because early active and passive motion is employed in the postoperative care.

Operative therapy gives almost immediate relief of the pain in the region of the radial styloid, and practically normal function of the thumb is permitted within a few days.

Compound F (Hydrocortone) has been injected in amounts of from 0.3 to 0.5 cc. (25 mg. per cc.) into the painful tendon sheath[10,12] In many cases it gave rapid (12 hours) relief of pain and permitted the patient to be symptom free and working in 24 hours Howard, Pratt and Bunnell[12] believe that patients so treated "may have recurrence and eventually need surgical correction." However, symptomatic relief apparently can be obtained in a short time by the use of Compound F.

Stenosing tenovaginitis may affect any of the other dorsal and volar compartments of the wrist, as pointed out by Burman.[4] The treatment by rest, operation or Compound F injections is the same as for de Quervain's disease.

CONTRACTURE OF THE PALMAR FASCIA

(Dupuytren's Contraction)

Pathology. The palmar fascia represents the palmar insertion of the palmaris longus muscle. It is of surgical importance because it frequently becomes involved in a process of hypertrophy and contraction. This hypertrophy usually begins as a nodular thickening along that portion of the palmar fascia overlying the flexor tendon to the ring finger. As the disease progresses, nodules appear also over the flexor tendons of the fifth and the middle fingers and may indeed involve also the index finger. With the hypertrophy, there is a gradual contraction of the portion of the fascia involved. Because of the vertical fibers of the palmar fascia which insert in the undersurface of the skin, there is an early involvement of the palmar integument, with at first a dimpling and then a gradual thickening (Fig. 381).

The longitudinal fibers of the palmar fascia extend to the sides of the proximal phalanges, and the contracting process involves these extensions and also the fascia of the finger. As the hypertrophy and later contraction progres
of the
mar fa
contracture of the proximal phalanx on the metacarpal bone. Gradually, the contracture involves also the middle phalanx until the entire finger is drawn down to such an extent that often it touches the palm.

Although the fascia extending to the ring finger is most frequently involved, the fascia to the fifth and the middle fingers also is a part of the contracture. The process also extends toward the wrist, and the thickened







Fig. 384 Stages in the development of Dupuytren's contracture. (*Top*) Note the thickening and the dimpling of the palmar skin in the distal flexion crease, with the typical involvement of the fourth finger (*Left*) Typical bilateral involvement with more marked contracture of the right fourth finger and beginning involvement of the left hand. (*Right*) Advanced stage of Dupuytren's contracture with involvement of the middle, the ring and the fifth fingers. The first 2 patients underwent surgery as ambulatory cases.

portion of the palmar fascia may be palpated and often seen as a ridge of hard tissue extending to the base of the hand The disease often is a bilateral one, and occasionally there appears to be a definite hereditary tendency

Etiology. As to the etiology, there is some division of opinion. Most writers on the subject feel that trauma is not an important factor in the production of the contraction, since it occurs with almost equal frequency in *those who use their hands and in* those who do not, such as lawyers, clergymen, physicians and bankers. However, there are those who feel that trauma plays an important role and others who think that trauma plus foci of infection are the important etiologic mechanisms. In a study of our own cases, trauma has not appeared to be an important factor, and we are inclined to agree with Kanavel, Koch and Mason[17] that a "hereditary tendency stands out as the most definite and tangible factor in the development of the disease."

Symptoms. The symptoms that occur with Dupuytren's contracture are few, except those due to the contraction. Frequently there is slight pain in the early stage of the disease in the region of the nodulations that appear, but usually this disappears rapidly, and the nodules may remain without any progression of the disease for months, and even years. There usually is no difficulty in diagnosing this lesion once it is seen.

Treatment. In treating Dupuytren's contracture, it is essential to recognize that the disease involves only the palmar fascia; it does not affect the underlying tendons. Therefore, excision of the fascia permits normal extension and flexion of the fingers involved because the tendons still are able to function in a normal manner. Operation for excision of the palmar fascia may be performed in ambulatory patients when the process is not too far advanced. However, when the dissection involves an excision of the contracted band along several fingers, and skin transplants are necessary, the patient is hospitalized for treatment.

We have performed excision of the palmar fascia in numerous ambulatory patients under local anesthesia. A *block of the median and the ulnar* nerves at the wrist is not too difficult a procedure, and, when further anesthesia is needed, local infiltration is added. A blood-pressure cuff is used as a tourniquet to permit careful and rapid dissection of the fascia. An incision is made along the distal palmar crease, and, with small forceps and tiny rake retractors, the contracted fibrous extensions from the palmar fascia to the skin are divided to expose the underlying hypertrophied fascia. The incision must be from 1½ to 2 in. long to permit the dissection to be carried downward far enough to excise the proximal portion of the contracted fascia. When this has been divided, the dissection is carried distally; the skin is dissected from the palmar fascia, and the extensions of the palmar fascia to the metacarpal bone and the interosseous fascia are divided. As the dissection is carried upward to the proximal phalanges of the finger, care must be taken to identify and avoid the digital nerves and vessels that lie embedded in the contracted fascia along the sides of the finger.

Occasionally it is necessary to make a second transverse incision at the crease between the palm and the finger, but this is made only after the dis-

section has been carried upward from below to the base of the finger. As the dissection progresses, the cut vessels can be seen in the cadaveric hemostasis produced by the blood-pressure tourniquet, and these are caught and tied. After excising the contracted portion of the palmar fascia, the tourniquet is released to identify any small bleeders that have not been recognized.

After adequate hemostasis is obtained by ligation with fine silk ligatures, the divided skin is united with fine alloy steel wire sutures. It is important to obtain accurate apposition of skin edges; the sutures are placed close to each other, and often vertical mattress sutures alternating with interrupted sutures are inserted. A pressure bandage, in which is incorporated sterile mechanic's waste or a soft-rubber sponge, prevents serum collections and capillary ooze. A palmar splint usually is applied, and the patient is given a sling. The pressure bandage should be inspected in 24 hours. However, the dressing is not changed and the sutures are not removed for from 7 to 10 days unless there is reason to suspect trouble in the wound. The author never has had an infection in an ambulatory patient following excision of the palmar fascia for a Dupuytren's contracture. Occasionally there is a slightly imperfect healing of the skin where it has been dissected away from the nodular thickening of the palmar fascia, but this heals usually by conservative treatment without scarring or difficulty.

The prognosis for normal function is excellent, especially in the earlier cases. As a rule, all dressings are discarded within a period of 2 to 3 weeks, and no special postoperative physiotherapy or exercises are necessary to obtain a good result.

There have been several reports concerning the use of roentgenotherapy in the treatment of Dupuytren's contracture. It is possible that by this method the pain of early contracture may be relieved, but, certainly, roentgenotherapy is not a substitute for excision of the palmar fascia in relieving the contraction.

CYSTS AND TUMORS

Post-traumatic Epidermoid Cyst

Etiology and Pathology. Cysts lined, at least in part, by squamous epithelium occur not infrequently in the hands and the fingers following trauma. They are seen mostly in those whose hands are liable to trauma, such as laborers, carpenters and so forth. In most instances, the injury is a perforating wound or a crush with laceration, but cases have been reported of simple crush without rupture or break of the skin.

The usual idea concerning this type of cyst is that there has been an implantation of epithelium below the surface of the skin that has grown and formed a cyst, hence the name implantation cyst for this lesion. However, as in a fair number of these patients cysts develop without any history of a break in the skin, King[20] has suggested that they arise not as a result of implantation of epithelial tissue but as a development of epithelium from the sweat glands adjacent to the area of trauma. Most frequently, the cyst does not appear immediately following trauma; rather, several years elapse before it begins to develop. Once it appears it grows rapidly, usually on the palmar surface of the hand or the fingers.

Symptoms. Ordinarily, examination

portion of the palmar fascia may be palpated and often seen as a ridge of hard tissue extending to the base of the hand. The disease often is a bilateral one, and occasionally there appears to be a definite hereditary tendency.

Etiology. As to the etiology, there is some division of opinion. Most writers on the subject feel that trauma is not an important factor in the production of the contraction, since it occurs with almost equal frequency in those who use their hands and in those who do not, such as lawyers, clergymen, physicians and bankers. However, there are those who feel that trauma plays an important role and others who think that trauma plus foci of infection are the important etiologic mechanisms. In a study of our own cases, trauma has not appeared to be an important factor, and we are inclined to agree with Kanavel, Koch and Mason[17] that a "hereditary tendency stands out as the most definite and tangible factor in the development of the disease."

Symptoms. The symptoms that occur with Dupuytren's contracture are few, except those due to the contraction. Frequently there is slight pain in the early stage of the disease in the region of the nodulations that appear, but usually this disappears rapidly, and the nodules may remain without any progression of the disease for months, and even years. There usually is no difficulty in diagnosing this lesion once it is seen.

Treatment. In treating Dupuytren's contracture, it is essential to recognize that the disease involves only the palmar fascia; it does not affect the underlying tendons. Therefore, excision of the fascia permits normal extension and flexion of the fingers involved because the tendons still are able to function in a normal manner. Operation for excision of the palmar fascia may be performed in ambulatory patients when the process is not too far advanced. However, when the dissection involves an excision of the contracted band along several fingers, and skin transplants are necessary, the patient is hospitalized for treatment.

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Occasionally it is necessary to make a second transverse incision at the crease between the palm and the finger, but this is made only after the dis-



Fig. 386. Xanthoma of the finger



Fig. 387. Fibroma of the thumb.

posed following incision, when, because of its distinctive color, it is diagnosed easily.

Removal by blunt dissection usually is simple (Fig. 386). Care must be taken to remove all the tumor, otherwise it may recur.

Fibromas and Lipomas

Many tumors, such as fibromas and lipomas, occur on both the dorsal and the palmar surfaces of the hand and the fingers (Fig. 387). When these are small, they may be removed easily under local anesthesia. Primary suture of the wound, a pressure bandage and splint are recommended.

Warts

Warty growths frequently are found on the hand and the fingers. Those occurring on the dorsum of the hand are treated best by excision and primary suture. Those on the palm and over the joints of the fingers are better treated perhaps by other methods—for instance, irradiation, fulguration under local anesthesia or injection of a drop or two of sclerosing solution into the base of the wart (p. 185).

Premalignant Lesions

Senile keratoses, horny cutaneous



Fig. 385. Epidermoid cyst of the finger This patient struck his finger on a nail 3 years before he sought treatment. The cyst became more apparent following a recent injury. It was shelled out easily under local anesthesia.

reveals a rounded or sometimes lobulated elastic mass adherent to the undersurface of the skin (Fig. 385), although it is sometimes free of this structure and occasionally occurs within the bone of the distal phalanx.[2] Post-traumatic epidermoid cysts rarely become infected, but they are sometimes painful, due to trauma.

Treatment. The treatment of these cysts is excision. This usually can be performed under local anesthesia, with tourniquet control of bleeding. The cysts are well defined, but they do not shell out as easily as the common sebaceous cyst. The wound is sutured primarily, and rapid healing results with little or no deformity.

Pilonidal Cyst of the Finger Web (Barber's Pilonidal Sinus)

Etiology. Those who deal with hair or hides may develop a cyst or a sinus of the foreign-body type. The cause of this is that short hairs pierce the skin and work their way into the subcutaneous tissues. The opening through which the hairs penetrate may drain a serous or slightly purulent fluid, and at times a definite granuloma (milker's granuloma) may form at the site. There may or may not be discomfort, depending on the amount of inflammatory reaction.

Diagnosis. The diagnosis is made by inspection. In the noninfected case, a small sinus opening is seen in the web of the fingers, from which short bits of hair protrude. The infected case shows a small granuloma.

Treatment. Excision or incision of the cyst may be carried out under local anesthesia. A protective adhesive shield should be worn over the scar until solid healing takes place.

Xanthoma

Etiology and Pathology. Xanthoma, or giant-cell tumor, of the tendon sheath is a nodular, coarsely lobulated, slow-growing swelling that occurs most frequently on the palmar surface of the fingers. It may occur also in the hand and the wrist. The tumor usually is not large or painful.

In appearance, xanthomas are mottled yellow-brown-gray in color, and usually they are not as well encapsulated as are cysts. On microscopic examination they are found to contain numerous types of cells, including spindle, large round cells, most characteristically large giant cells and collections of large lipoid-containing foam cells.

Treatment. Excision is performed for either cosmetic or functional reasons. The true nature of the tumor often is not suspected until it is ex-

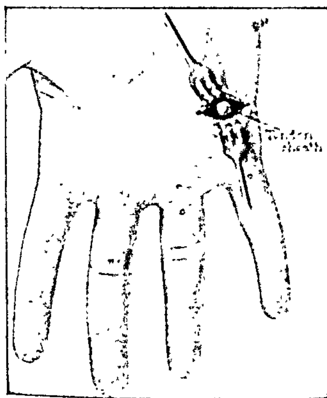




Fig. 389 (*Left*). Common ganglion on the flexor tendon sheath of the palm The circles indicate the usual positions of these ganglia This drawing was made at the time of operation and shows the approximate size of the ganglion. Its removal is not followed usually by recurrence, and complete relief of the pain is obtained. (DeOrsay, Ralph H., Mecray, Paul M., Jr., and Ferguson, L. Kraeer. Am. J Surg. 36:313)

Fig 390 (*Right*). Congenital phlebectasia of the dorsum of the fifth finger. This patient was treated by excision of the cluster of congenitally enlarged veins.

this kind that we have seen, definite fluctuation was obtained, suggesting that the contents were more liquid than is usual in ganglia. However, aspiration was not successful, whereas excision produced a cure. Surgery usually is performed in this type of ganglion to improve the appearance of the finger (Fig. 388).

The common type of ganglion of the finger is a small hard cyst rising from the flexor tendon at the base of the finger (Fig. 389). It appears usually as a nodule about as big as the head of a match, and is is extremely painful on pressure. Because of the extremely hard nodule, most of these cases are diagnosed as a chondroma or bony tumor.

Treatment. Excision under local anesthesia through a transverse incision produces rapid and complete cure of the pain that these small ganglia cause.

Ganglia of the Hand

Distal Palm Ganglia

Ganglia occur in the distal portion of the palm along the flexor tendon sheaths As in the fingers, they are small hard, rounded nodules that often are mistaken for bony or carti-



Fig. 388. Large fluctuant ganglion on the palmar surface of the finger. This ganglion was treated by excision under local anesthesia. (DeOrsay, Ralph H., Mecray, Paul M., Jr., and Ferguson, L. Kraeer: Am. J. Surg. 36: 313)

growths and pigmented nevi that occur on the hand should be regarded as premalignant lesions. They may be excised easily under local anesthesia, and this is recommended as a form of prophylactic treatment.

Ganglia of the Fingers

The general subject of ganglia has been discussed earlier (Chap. 12, p. 205), but special mention should be made of those occurring on the fingers and the hand.

Dorsal Surface Ganglia (Mucoid Cysts)

On the dorsum of the fingers, these lesions appear usually in the region of the distal interphalangeal joint or over the base of the distal phalanx (Fig. 127, *right*). They arise as small, rounded, painless firm tumors, over which the skin is thinned out and stretched. They give no symptoms, but they are disfiguring and occasionally give pain if they are traumatized.

Treatment. Conservative treatment of these small ganglia of the dorsum of the fingers usually is unsuccessful. They do not respond well to attempted rupture or aspiration. They may be excised easily through a transverse incision under local anesthesia. The wound is sutured primarily, and healing occurs rapidly. Recurrence is frequent, often in an adjacent area following excision. Several authors [9,13,14,19] have recommended roentgen treatment of the area and report complete and permanent disappearance of the cyst. Although the author has had no experience, he considers it worth a trial to instil a drop of Compound F (Hydrocortone) into the mucous cyst. Howard, Pratt and Bunnell[12] report good results in 2 cases treated in this way.

Palmar Surface Ganglia (Flexor Tendon Ganglia)

Description. On the palmar surface of the fingers, there is a common type of ganglion and a relatively rare type. The rare type is a large ganglion that appears to rise from the flexor tendon sheath over an entire phalanx or several phalanges. In the few cases of

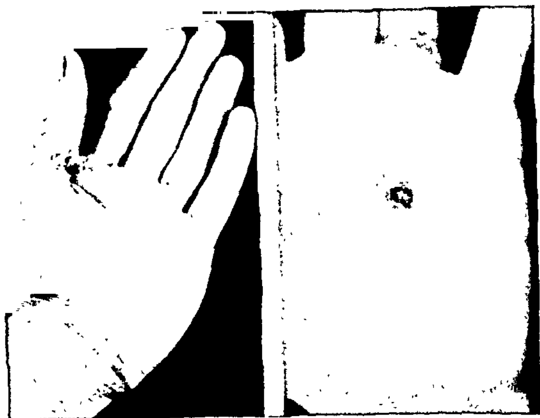


FIG. 391. Infectious granulomas of the finger and the palm of the hand. These tumors were treated by cauterization with a silver nitrate stick; rapid healing took place.

tion before injection. In the experience of the author, aspiration of the gelatinous content of the ganglion has been difficult, if not impossible, even when a large-sized needle was used. However, puncture by passing an 18-gauge needle through the ganglion is possible under local anesthesia. Such a puncture allows enough of the gelatinous material to escape into the tissues to permit the injection of 12.5 mg. (½ cc.) of Hydrocortone. Very little discomfort is experienced. No dressing is necessary unless there is bleeding from the needle punctures. In the experience of the author, the ganglia have disappeared with relief of the discomfort present previously. The possibility of recurrence cannot be ruled out. Howard, Pratt and Bunnell[12] report poor results by this method of treatment, and one author reports that poor wound healing may occur if surgical excision is attempted soon after injection with Hydrocortone.

Vascular Tumors

Congenital Phlebectasia

Symptoms and Diagnosis. This is a rather infrequent lesion of the fingers. It produces marked deformity and, occasionally, pain due to pressure on adjacent nerves. It is recognized easily as a bluish subcutaneous enlargement in the fatty tissues, usually at the side or on the dorsum of the finger (Fig. 390).

Treatment. These lesions may be treated either by injection of a small amount of sclerosing solution (see p.

laginous tumors. They cause pain due to pressure when the patient grasps hard objects.

Treatment. Excision under local anesthesia through a transverse incision gives complete relief. These ganglia do not tend to recur after excision.

Ganglia of the Dorsum of the Hand

Ganglia may occur also on the dorsum of the hand within the extensor tendons. These appear as small hard nodules in the tendon itself, and frequently they are not diagnosed until operation. They may cause symptoms due to tension within the tendon substance.

Treatment. The ganglion may be exposed under local anesthesia, and either it is excised from the tendon or the part of the tendon involved may be excised, a portion of the longitudinal fibers being left in place. Careful wound closure usually gives a good result (Fig 126, *right*).

Wrist Ganglia

Ganglia occur frequently on the wrist – on the dorsal, the anterior or the lateral surface. Often they give symptoms of pain and discomfort when the wrist and the hand are used, but in the majority of cases symptoms are relatively few, and the patient seeks treatment because of disfigurement.

Treatment. The ganglia of the dorsum of the wrist can be treated most successfully by rupture and dispersion. Simple pressure with the thumb or striking the ganglion with a book when it has been made prominent by flexion of the wrist may cause complete disappearance, without recurrence, in about 50 per cent of the cases.

Aspiration and injection of ganglia have not comprised successful treatment in the author's experience.

Excision is the method of choice and the one that gives the best results. This may be performed under local infiltration anesthesia, through either a transverse or a longitudinal incision. The ganglion, which is found most often in the region of the transverse carpal ligament, is exposed by gentle blunt dissection. As a rule, if it is found to extend between the tendons down to the joint capsule, complete excision is necessary to avoid recurrence. After the ganglion has been removed, the soft tissues are united to cover the exposed tendon, and the skin is closed with mattress sutures of fine wire. A pressure bandage is applied, but splinting is not necessary. Following operation, there usually is considerable swelling of the dorsum of the hand for a day or two, so that elevation in a sling must be enforced. The sutures are allowed to remain in place for at least 7 to 10 days. When they are removed, a firm bandage is applied for another 4 or 5 days, then normal function may be resumed without dressing.

Compound F (Hydrocortone) for the Treatment of Ganglia[30]

The injection of ganglia with Compound F has been suggested and employed with varying results. The idea of reducing a painful inflammatory reaction by the local injection of Hydrocortone seems to be logical, but there is some difficulty in demonstrating an inflammatory process in ganglia. Nevertheless, injection of ganglia with Compound F has proven to be very interesting. Some suggest aspiration of the ganglion and even irrigation with procaine or saline solu-

be treated by elliptical excision, as suggested by Mason, or, more conservatively, by simple cauterization with a silver nitrate stick; we have found the latter to be sufficient. One or two applications of silver nitrate usually will cause the tumor to disappear. However, in some cases, simple excision with scissors followed by application of a silver nitrate stick to the tumor base is effective.

Glomus Tumor

Pathology. This is a tumor of the neuromyo arterial glomus of Masson, an arteriovenous anastomosis found scattered through the skin of the extremities that has to do with regulation of the local circulation (see p. 198). Abnormal enlargement of this structure may give symptoms.

Symptoms. Tenderness is the predominant symptom in practically all cases, and it is most marked when the tumor occurs under the nail. When it is pressed upon, spontaneous attacks of pain occur with proximal radiation. In a large percentage of cases, pain is produced by changes of temperature. Some patients are affected more by exposure to cold, others are more sensitive to heat. The tumors under the nail appear as a bluish or a reddish-blue area, and in the skin they are identified by the same characteristic. Pressure over the tumor may cause a disappearance of the color, and usually it produces marked pain.

Treatment. Excision is the method of choice in the treatment of these tumors. It may be carried out under local anesthesia by blocking the distal nerves at the base of the finger. A rubber-tube tourniquet makes a bloodless field, but, before it is put on, the area of the tumor must be marked because the color is absent after the tourniquet is applied. In subungual tumors, it is well to remove the entire nail to obtain adequate exposure for complete removal of the glomus.

Tumors of the Periosteum and Bone

Chondromas of the Periosteum of the Phalanges

Description. The less common type of chondroma springs from the periosteum of the phalanges. It occurs as a hard round tumor of considerable size that produces deformity and disability. A roentgenogram usually shows some deformity of the underlying phalanx, but not an involvement of the bone proper (Fig. 392).

Treatment. Excision of this tumor under local anesthesia usually is a simple matter. It is well encapsulated, and it is unlikely to recur after it has been removed.

Chondromas of the Metacarpal Bones and Phalanges

Pathology. Probably the more common type of chondroma is that which occurs in the shaft of a metacarpal bone or a phalanx. The cortex is expanded markedly over one half or two thirds of the circumference of the bone, and the tumor usually remains within the cortex. Frequently, there is some pain due to pressure on nerves that are stretched over the expanding tumor mass.

Diagnosis. The roentgenogram shows a characteristic enlargement of the bone without the definite trabeculations seen in giant-cell tumor, which is the only tumor likely to be confused with chondroma.

Treatment. This consists of complete removal of the tumor tissue with a curet, and Mason[25] recommends chemical sterilization of the cavity

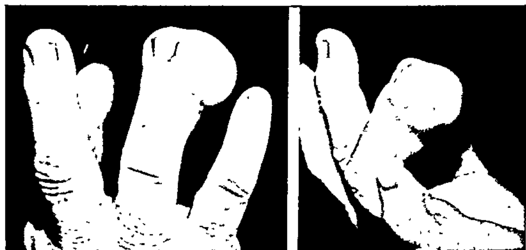




Fig. 392. Chondroma of the distal phalanx removed under local anesthesia. When this tumor was removed, only a shell of skin remained, but an excellent cosmetic and functional result was obtained.

196) or by excision of the enlarged vessel.

Telangiectatic or Pyogenic Granulomas

Description and Pathology. This lesion occurs infrequently on the hand and the fingers (Fig 391). It is a pedunculated, mushroom-shaped, red granular tumor, the surface of which often is crusted and bleeds easily. Most frequently the granuloma follows trauma with secondary infection, although the tumor differs from the usual type of granulation tissue. Mason[25] has found it to consist of a base of vascular or telangiectatic spaces, from which arises a body of granulation.

Treatment. These granulomas may



FIG. 394. Multiple exostoses of the bones of the hands

with Zenker's solution or 50 per cent zinc chloride. This operation may be performed under local block anesthesia with tourniquet hemostasis.

Giant-Cell Tumors

Symptoms and Diagnosis. This tumor occurs in the phalanges of the fingers. It produces a swelling and an enlargement of the phalanx involved. There are few other symptoms, except an occasional pain due to pressure on adjacent nerves. A roentgenogram makes the diagnosis easy, demonstrating frequent trabeculations throughout the tumor mass (Fig. 393).

Treatment. Mason[25] recommends complete local excision with a curet, followed by chemical cauterization of the cavity. He believes that irradiation is of uncertain value. However, some favorable results have been seen from this method of therapy (Fig. 393).

Exostoses

Exostoses are seen only rarely on the bones of the hands; occasionally, they occur as multiple lesions (Fig. 394) When they cause symptoms, they may be removed easily under local anesthesia by chipping away the bony excrescence.

Subungual exostoses are not nearly as frequent in the fingers as in the toes When they do occur, they cause considerable pain due to pressure. Their removal relieves the patient's symptoms (Chap. 24).

CONGENITAL DEFORMITIES OF THE FINGERS

Supernumerary Digits

Extra fingers are seen occasionally, and frequently they are bilateral. At times, they are attached by only a small fibrous pedicle (Fig. 395); at others, true bony connection is noted. In many cases, especially when the supernumerary finger springs from a metacarpal bone, simple excision of the finger and of the outgrowth of bone from the metacarpal is all that is necessary to obtain a good result. The operation may be performed under local anesthesia (Fig. 396).

Supernumerary Phalanges

Treatment. Duplication of the distal phalanx or the distal two phalanges of the thumb is a frequent congenital deformity (Fig. 397). Often this is bilateral, and operation is not always a simple matter because both the normal and the supernumerary

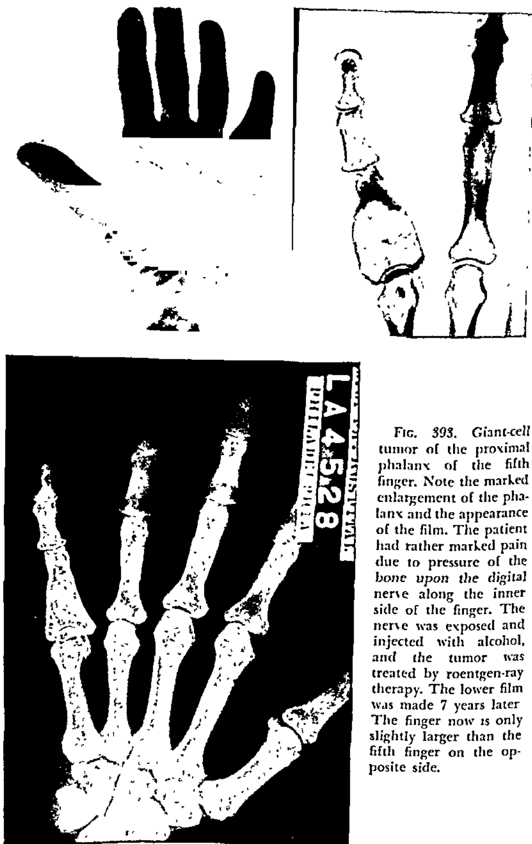


Fig. 393. Giant-cell tumor of the proximal phalanx of the fifth finger. Note the marked enlargement of the phalanx and the appearance of the film. The patient had rather marked pain due to pressure of the bone upon the digital nerve along the inner side of the finger. The nerve was exposed and injected with alcohol, and the tumor was treated by roentgen-ray therapy. The lower film was made 7 years later The finger now is only slightly larger than the fifth finger on the opposite side.



FIG. 394. Multiple exostoses of the bones of the hands

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CONGENITAL DEFORMITIES OF THE FINGERS

Supernumerary Digits

Extra fingers are seen occasionally, and frequently they are bilateral. At times, they are attached by only a small fibrous pedicle (Fig. 395); at others, true bony connection is noted. In many cases, especially when the supernumerary finger springs from a metacarpal bone, simple excision of the finger and of the outgrowth of bone from the metacarpal is all that is necessary to obtain a good result. The operation may be performed under local anesthesia (Fig. 396).

Supernumerary Phalanges

Treatment. Duplication of the distal phalanx or the distal two phalanges of the thumb is a frequent congenital deformity (Fig. 397). Often this is bilateral, and operation is not always a simple matter because both the normal and the supernumerary



FIG. 395. Supernumerary digits attached by small pedicles. These can be removed very easily in infants under local anesthesia. It must be remembered that these pedicles always contain a small central vessel which must be ligated or sutured carefully.

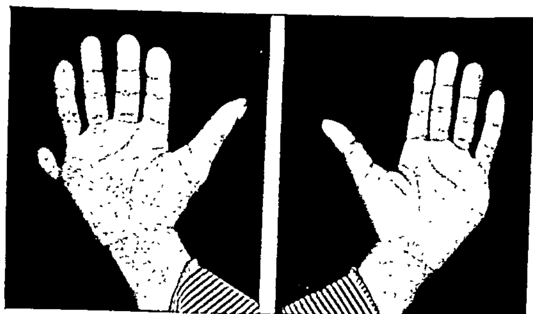


FIG 396. Supernumerary digits. This boy had extra digits on both hands as shown (*left*). (*Right*) The result on the left hand 3 weeks after excision of the accessory digit under local anesthesia.

portion of the digit take part in the interphalangeal joint. Removal of the supernumerary portion may result in a disturbance of the joint function without marked improvement in either function or appearance. In some cases of bifid thumb, Meyerding and Dickson[29] suggest excision of the central half of both parts of the distal phalanx, uniting the lateral portions to make one single phalanx. Operations for syndactylism usually are tedious procedures, and they are necessary mostly in children; therefore, hospitalization usually is recommended.

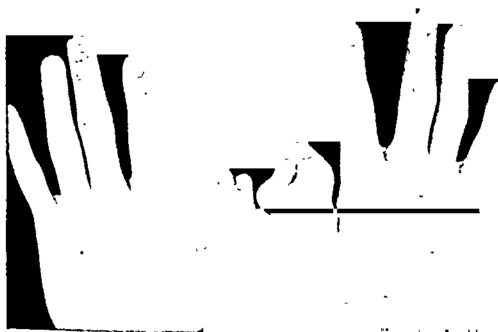


Fig. 397. Supernumerary distal phalanges. Operation for and repair of this type of congenital deformity is not such a simple matter because of the disturbance of joint function which follows removal of one portion of the supernumerary finger.

KIENBÖCK'S DISEASE OF THE CARPAL SEMILUNAR (LUNATE) BONE

Etiology. Kienböck's disease is the name given to a subchondral osteonecrosis of the carpal semilunar bone. The disease is a slowly progressive one, usually aseptic bone necrosis followed by fibrous-tissue replacement. It occurs mostly in healthy young males, and it is believed to be due to trauma that produces either a fracture of the bone or contusion of the cartilaginous surface. Partial displacement with spontaneous reduction may be a cause in some cases. The disease probably is caused by an interference with the blood supply of the semilunar bone due to trauma.

Symptoms. The onset of the disease is insidious. The injury may be a relatively minor one, but usually the patient is able to connect the onset with some injury or strain of the wrist. He complains of gradually increasing pain in the wrist, with moderate stiffness and some thickening in the region of the joint. On examination, swelling and thickening are noted in the anteroposterior diameter, mostly on the dorsum of the wrist. Acute tenderness is present, localized to the center of the wrist on its dorsal surface. Active and passive motion of the wrist is limited, active motion may be extremely painful, so that it may be almost impossible even to make a fist.

Diagnosis. A roentgenogram is of great value in establishing the diagnosis. The appearance of the bone is quite typical—an increased density of the shell of the cortex of the semilunar bone and areas of decalcification with, occasionally, a splitting of the bone

in two parts. The decalcification is mostly in the proximal side of the bone, that is, near the radius.

Treatment. In a few cases, a plaster cast or splint that supports and immobilizes the wrist results in a cure. This must remain in place for at least 4 months. However, in the majority of cases of well-established disease, removal of the semilunar bone through a dorsal incision usually is performed. This procedure is carried out best in the hospital.

REMOVAL OF RING FROM SWOLLEN FINGER

Occasionally the surgeon is called upon to remove a ring from a swollen finger. Attempts at removal by the use of soap or oily preparations having failed, the temptation is to try to cut the ring. Often this will prove to be difficult if the finger is much swollen, and especially if the patient is a child.

A piece of stout string about 50 in. long may be used to remove even a tight ring. Soap the string and then *thread about 2 in. of it under the ring* toward the wrist. This is held tight while the remaining string is wrapped snugly round the finger, one wrap next to the other, until the finger is covered beyond the proximal interphalangeal joint. The distal end is held tight. The ring is removed by pulling upward on the end threaded through it. As the string is unwound from the bottom, the ring is removed gradually, advantage being taken of the fact that the tightly wound string has compressed the soft tissues over the joint.

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■ 24 ■

The Leg

CALCAREOUS TENDINITIS ABOUT THE GREATER TROCHANTER

Symptoms and Diagnosis. Without any injury, or after a trifling one, there is an onset of pain about the greater trochanter that rapidly becomes worse and is so severe that it prevents walking. Examination discloses acute tenderness over the greater trochanter. Roentgenograms show the characteristic calcareous areas (Fig. 398); the asymptomatic side may show similar areas.

Treatment. In the treatment of calcareous tendinitis (see p. 462), an injection of from 20 to 30 cc. of 1 per cent procaine, using a large-bore needle, is particularly efficacious. This may be repeated several times if necessary.

INGUINAL ADENITIS

Secondary involvement of the inguinal nodes is a frequent complication following a primary infection in the foot and the leg or in the perineum. The nodes involved lie below



Fig. 398. Calcareous tendinitis at the greater trochanter. (*Left*) Shows a small calcareous area on the asymptomatic side. (*Right*) Shows 2 areas on the acutely painful side. Complete relief followed 2 injections of procaine, no treatment was given the painless side. (Kaplan, Louis: Pennsylvania M. J. 45:37)

the inguinal ligament. Therefore, the swelling is in the upper inner side of the thigh and causes pain that is increased by walking.

Every patient with an infection of the foot and the leg or of the perineum should be examined for enlargement and tenderness of these nodes, because early treatment of both the primary focus and the secondary adenitis may result in subsidence of the lymph node infection.

If the patient is seen early, local moist heat usually permits the infection to subside. Frequently, however, although the nodes may enlarge slightly during the primary infection, they may subside and appear innocent for a time, only to reappear at a later date, perhaps weeks after the primary infection has subsided. The adenitis is characterized by redness, tenderness and temperature elevation, and, as time goes on, fluctuation may appear. When there is fluctuation or the duration of the infection in the group of lymph nodes suggests pus formation, incision and drainage are indicated. This is accomplished under a general anesthesia in cases in which there is no superficial fluctuation; but, when there is a definite fluctuant swelling, the incision may be made under local anesthesia. After removal of the pus by sponge or aspiration, an iodoform-gauze drain is inserted into the abscess, and a pressure dressing is applied with a spica-type bandage. Then the patient may be treated at home by hot wet dressings and present himself at the office for treatment at 2- or 3-day intervals. As soon as the slough has been removed completely, the wound is permitted to heal by granulation. These infections usually are caused by the staphylococcus or the streptococcus, organisms that are controlled readily by penicillin. If they are seen early, pus formation may be avoided by penicillin administration. If fluctuation indicates pus formation, incision is obligatory, but penicillin may be used as a prophylactic to prevent spread of the infection and to hasten subsidence of the inflammation.

CONTUSIONS OF THE THIGH

The thigh is one of the most frequent sites of contusion (Fig. 399). This area is bruised frequently in all types of contact sports, especially football, and also in various forms of industrial and civil accidents. The large fleshy muscles of the thigh are bruised against the femur, the result being a considerable amount of hemorrhage and swelling.

Symptoms. At first, the injury may give an almost paralyzing pain that disappears rapidly, however, in from 24 to 48 hours, the thigh becomes more swollen and painful, and the part feels stiff during attempted function.

Treatment. If the injury is treated early, the application of cold for an hour or more is beneficial, but by far the most important therapeutic measure is a firm pressure bandage. Elastic adhesive applied in a spiral manner from the knee up to the groin is very effective, and the earlier it is applied, the less the hemorrhage, and, therefore, the less the disability (Fig. 400). This pressure should be maintained for from 2 to 3 weeks, unless the skin under the adhesive begins to show signs of irritation. After 2 or 3 days, the application of heat may be of value, but usually ordinary function may be resumed at the end of this time. We believe that this is more satisfactory than physiotherapy in dispersing the hematoma and in pre-

▪ 24 ▪

The Leg

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may be an actual rupture of the muscle in its belly. All these lesions are the result of a forceful abduction of the leg while the muscle is contracted. In horseback riding, this occurs especially in jumping, when the thighs are adducted to hold the rider in his saddle, the saddle being thrust up between the thighs, which pushes the legs apart.

Symptoms. The symptoms produced are typical. The patient complains of pain in the upper inner portion of the thigh, and adduction becomes so weak that often he is unable to continue riding.

Diagnosis. On examination, the findings vary somewhat according to the type of injury. In muscle rupture, swelling and ecchymosis of the thigh are definite; at times it is possible to feel an area of depression, which marks the site of the muscle tear. Muscle strains are characterized by tenderness of the adductor muscle in the upper inner part of the thigh when it is palpated between the fingers. A tear of the muscle origin is indicated by the marked tenderness along the ischial ramus on palpation. All these muscle injuries show definite pain when the knees are forced apart while the patient is attempting to hold them together.

Treatment. This is similar for the various lesions. Elastic adhesive bandages, applied firmly to the thigh up to the groin, give good support and frequently relieve most of the discomfort. Applications of heat are of value. As a rule, the patient has little difficulty in pursuing ordinary activities, but motions necessitating forceful adduction of the thigh should be avoided. Recovery eventually takes place, but the muscle may remain painful for 4 to 6 weeks.



Fig. 100 Elastic adhesive bandage of the thigh in treating contusion. If this dressing can be applied early, hemorrhage and swelling are decreased greatly. It is applied from below upward, each layer being overlapped one half. The ends must be secured with adhesive strips to prevent rolling.

RUPTURE OF THE QUADRICEPS EXTENSOR MUSCLE

Etiology. The quadriceps extensor muscle is ruptured occasionally by a violent muscular effort to recover balance. Rupture occurs when the lower leg is nearly in line with the thigh, whereas the patella is fractured over the condyles of the femur if the same effort is exerted with the knee flexed.

The muscle tears above the patella, and, because of the broad insertion of the quadriceps extensor in the patella, usually the entire insertion is not torn.

Symptoms. Usually, considerable swelling is associated with the rupture. This is due to hemorrhage in the area. This marked swelling, in the center of which is a definite depression, is



FIG. 399. (*Left*) Contusion of the thigh (*Right*) Contusion with hematoma of the thigh; in this case, it was necessary to make a small incision to drain the hematoma.

venting adhesions between muscle bundles, which produce stiffness and soreness and thus prolong disability in these lesions.

As mentioned above, this injury occurs *frequently in contact sports*, especially in football It is difficult to treat these patients because often they want to continue playing. As is the case of a plasterer's sore thumb, so in sports, the injured part is certain to become the seat of a secondary injury with recurrence of contusion at the same site Saturday after Saturday in each football game. It is worth while with these patients to protect the injured area with some hard, unyielding pad, which we have made of tin or firm cardboard padded with sponge rubber. It must be large enough to cover completely the area of the primary contusion. If repeated injury can be prevented by this means, it is quite possible for the player to continue at his game.

STRAINS AND RUPTURES OF THE ADDUCTOR LONGUS MUSCLE

(Rider's Strain)

Etiology. There are various types of traumatic lesions of the adductor longus muscle, and, since they occur especially in horseback riding, they are mentioned sometimes under the general heading of rider's strain. The muscle may be pulled from its origin on the ramus of the ischium, there may be a tendon-muscle strain in the upper part of the muscle, or there

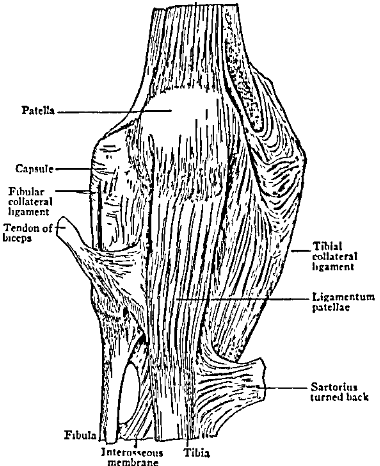


Fig. 102. Right knee joint from before.

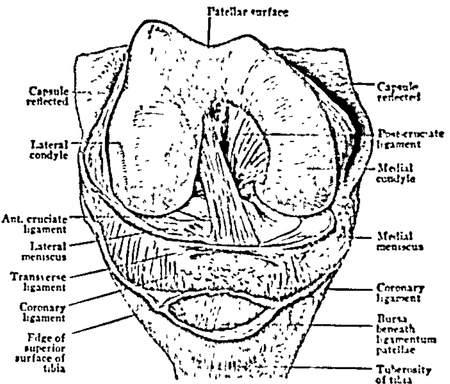


Fig. 103. Right knee joint opened and the knee flexed. Seen from before.

(Piersol. Human Anatomy, ed. 9, Philadelphia, Lippincott)

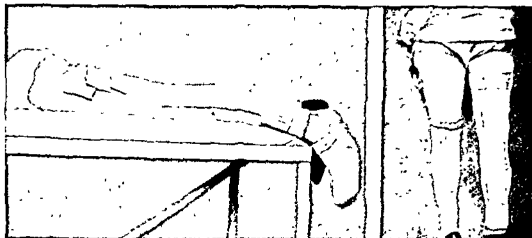


FIG. 401. Application of a posterior splint of Castex for immobilization of the knee Stockinet is drawn up from the ankle to the buttock, and a felt pad is laid at each end. When the splint is hard, the stockinet is turned back and fastened with adhesive. The splint is secured to the leg with wide adhesive straps. Three have been applied. A fourth is placed below the knee. An elastic bandage is wrapped round the knee to control swelling.

sufficient to make the diagnosis. The patient shows a weakness and often complete inability to extend the leg against resistance, and pain is experienced when this motion is attempted.

Treatment. Because of the fact that frequently the rectus femoris portion of the quadriceps is torn, whereas the vasti internus and externus remain intact, it is unnecessary usually to suture the ruptured muscle. The leg is splinted in extension, either a molded plaster splint or one of the lighter cast materials, such as Castex (Fig. 401), being used. The area of hemorrhage is padded with cotton or rubber-sponge material and bandaged firmly After 2 or 3 days in bed with elevation, the patient may be permitted to be about if the leg is held in complete extension by the posterior splint. A firm elastic bandage is maintained for a period of 5 or 6 weeks at least. Healing with normal function is the rule, but a period of from 8 to 10 weeks usually is necessary before complete normal function is resumed.

INJURIES TO THE KNEE JOINT

General Considerations

Anatomy. Although the knee joint is exceptionally strong, frequently it is the site of injury due to the great violence exerted on it and due to the length of the tibia and the femur, which act as powerful levers when the extremes of motion are reached. The essential motion of the knee is in flexion and extension. Slight rotation is possible in semiflexion, almost none in full extension. There is practically no sidewise motion.

The knee joint has a strong capsule reinforced anteriorly by the quadriceps tendon, the patella and the patellar ligament and on the sides by strong lateral ligaments. The lateral ligaments lie toward the posterior portion of the joint; thus they become tense in extension and relaxed in flexion (Fig. 402). On the posterior aspect, the expansion of the tendon of the semimembranosus acts as a reinforcement. The joint is strengthened further by the two crucial ligaments

of Knee Injuries

Abnormal Mobility	Tenderness	Pain on Motion
None	Internal cartilage anteromedial edge of tibial articular surface External cartilage anterolateral edge of tibial articular surface	On extension
None	Medial side of knee posteriorly	On extension
Leg may be abducted at knee	Medial side of knee	On abduction of leg at knee
Leg may be adducted at knee	Lateral side of knee	On adduction of leg at knee
Leg may be abducted at knee	Lateral side of knee and tibia	On abduction of leg at knee
Leg may be pulled forward if the anterior ligament is torn, or pressed backward if the posterior is torn	Diffuse	On flexion and extension
None	Just to each side of patellar ligament	Some pain on extension
None	Over dislocated patella and anterior aspect of knee	Pain on flexion
None	Over patella	Pain on flexion
None	Over lower portion of patella	Mild pain on flexion

With the patient sitting or lying down, the knees are placed in extension. Deformity, swelling, discoloration and limitation of extension are seen at a glance. The joint is palpated carefully for tender points and for its bony contours. Flexion is tested, and any pain and limitation of motion are noted. Mobility laterally and anteroposteriorly then is determined. (Fig. 404)

Preliminary Treatment of Acute Injuries About the Knee Joint. Acute traumatic synovitis and injuries of the cartilages, the ligaments, bone and the extensor apparatus have certain effects in common. Pain and swelling develop, with effusion or hemorrhage into the joint. (Fig. 405) Motion is painful, and often there is considerable muscle spasm.

After the initial examination is made, aspiration of blood or serous fluid from a tense joint relieves much of the pain and removes a source of irritation and fibrosis (see Fig. 407). A posterior splint (Fig. 406) of wood, metal or plaster is applied securely.

SUMMARY TABLE

INJURY	CAUSE	PAIN	LIMITATION OF MOTION
1 Semilunar cartilage injury	Rotation of flexed knee with foot fixed	Diffuse in entire knee	Knee may be locked in flexion
2 Sprain of internal lateral ligament	Adduction of knee with foot fixed	Posteromedial aspect of joint	Extension limited
3 Rupture of internal lateral ligament	Extreme adduction of knee with foot fixed	Medial side of knee	None
4 Rupture of external lateral ligament	Extreme abduction of knee with foot fixed	Outer side of knee	None
5. Fracture of external tuberosity of tibia	Extreme adduction of knee with foot fixed	Outer side of knee	None
6 Rupture of crucial ligaments or fracture of spines of tibia	Excessive backward or forward thrust, or hyperextension	Diffuse in knee	None, or there may locking
7. Hypertrophic fat pad	Previous mild injury	Just to each side of patellar ligament	There may be slight limitation of extension
8. Dislocation of patella	Lateral thrust on patella with congenital predisposition	About dislocated patella, usually anterolateral aspect of joint	Flexion limited
9. Fracture of patella	Direct violence or abrupt flexion	Over patella and knee	Loss of active extension
10. Prepatellar bursitis	Direct violence	Over lower half of patella	None

within it The anterior crucial runs from in front of the tibial spine upward, backward and outward to insert on the outer condyle in the intercondylar notch. The posterior crucial runs from the posterior groove upward, forward and inward to insert on the inner condyle in the intercondylar notch (Fig 403).

Over the tuberosities of the tibia lie the semilunar cartilages, C-shaped fibrocartilages with their thick outer margins, 6 to 8 mm., attached to the tibia by the coronary ligaments. The medial margins are thin and free. The external cartilage moves more freely than the internal. Both serve to deepen the slight concavity of the articular surface of the tibia. They move forward and backward to accommodate to the changes in the articulating surfaces of the femur on the head of the tibia in extension and flexion.

Examination of the Knee Joint. The patient's ability or inability to walk gives the first clue as to the state of the joint. Serious injuries make walking almost impossible



Fig. 405. (*Top*) Anterior and lateral views of effusion in the knee joint, with fullness visible above the right patella The knee cannot be extended fully. (*Bottom*) Anterior and lateral views of a prepatellar bursitis shown for comparison Note that the swelling is anterior and distal to the patella, and that there is no fullness above the patella.

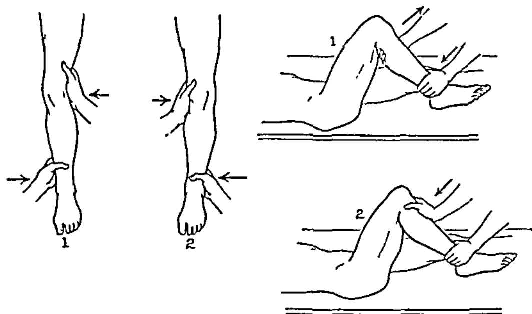


FIG. 101 Tests for ligamentous injury of the knee. (*Left*) The internal lateral ligament is tested by forcing the leg into abduction on the thigh (1). The external lateral ligament is tested by forcing the leg into adduction on the thigh (2) (*Right*) Testing for rupture of the crucial ligaments If the upper end of the tibia can be pulled forward (1), the anterior crucial ligament is torn. If the upper end of the tibia can be pushed backward (2), the posterior crucial ligament is torn.

Wood or aluminum is preferable if a roentgen examination is to be made. A firm pressure dressing of flannel or elastic bandage or of a thick layer of absorbent cotton secured with a muslin bandage then is applied. This aids in preventing further effusion into the joint. A roentgen study is made when indicated. The patient is instructed to keep the leg elevated and to apply ice bags about the knee for from 24 to 48 hours after the injury. *Salicylates and phenobarbital or codeine are given for pain.*

HEMARTHROSIS AND EFFUSION INTO THE KNEE JOINT

Etiology and Diagnosis. Effusion and hemorrhage into the knee joint follow injuries to the ligaments, the semilunar cartilages, the articular cartilages and the synovial lining and fractures of the femoral condyles, the spines of the tibia and tibial tuberosities. There may be a small or a large collection of fluid. Small amounts are detected by comparing both knees in full extension and observing any fullness of the hollows present normally at the the sides of the patella and proximal to it. When there is considerable effusion, the capsule of the joint is distended, and an inverted U-shaped swelling of the joint occurs. The dense patellar ligament prevents distention of the capsule beneath it, so that the swelling has its characteristic shape.

This condition must be differentiated from effusion into the prepatel-

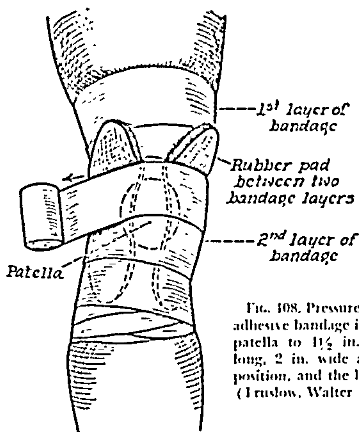


FIG. 408. Pressure dressing for the knee. An elastic adhesive bandage is applied from 4½ in. below the patella to 11½ in. above it. Rubber pads 8 in. long, 2 in. wide and ¼ in. thick are placed in position, and the bandage is continued over them. (Truslow, Walter[18] J. A. M. A. 110:285)

the blood is not removed, it is absorbed partly. Part may undergo organization with the formation of adhesions or bands in the joint.

Treatment. Very small effusions require only a firm pressure dressing of flannel or elastic bandage in addition to the treatment of the main injury. When the effusion or the hemorrhage into the joint distends the capsule or causes pain, the joint contents must be removed by aspiration, which relieves pain by relieving tension and removes a source of irritation and fibrosis.

Aspiration of the Knee Joint. After cleansing the skin with 2 applications of 70 per cent alcohol, a skin wheal is made with procaine solution 1 cm. medial to the lower half of the patella. A large-bore 16- to 18-gauge needle, attached to a 10- or a 20-cc. syringe, is introduced through the wheal and directed upward and outward toward the center of the joint. When the joint is entered, the contents can be withdrawn freely. As much fluid as possible is removed. If pressure is made on the joint and over the suprapatellar bursa, the fluid often can be pushed toward the site of the needle.

An alternate site of aspiration in marked effusion is from the distended suprapatellar portion of the joint capsule lateral to and above the patella (Fig. 407). The technic of aspiration is the same as described above.

Following aspiration, a posterior splint and a pressure bandage are applied. Continuous elastic pressure[5,17] is obtained by incorporating pads of sponge rubber in the dressing and by applying elastic or flannel bandages (Fig. 408). Reaspiration may be performed as necessary.

There need be no fear of aspirating the knee joint if a sterile needle and syringe and alcohol sponges are avail-



FIG. 406 Application of a posterior splint to the knee. A padded splint is applied to the knee with wide adhesive strips. The shaped wooden splint is shown for comparison. A firm flannel bandage is applied to complete the dressing.

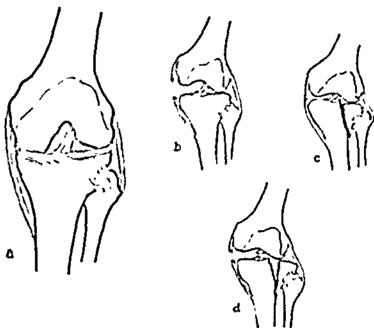
lar bursa. Bursal swelling distends the bursa, which lies mainly over the lower portion of the patella, between it and the skin. Effusion into the joint lies posterior to the patella, while bursal swelling is anterior to it (see Fig. 405). With the knee extended, a large effusion causes the patella to "float," that is, to be lifted away from the femoral condyles. By a sharp thrust, the patella may be made to click against the condyles. Complete extension and flexion often are impossible because of the joint tension produced by the effusion.

Distention of the joint by effusion or hemorrhage causes considerable pain and disability. If the exudate or



FIG. 407. Aspiration of the knee joint. The needle is inserted in the lateral surface of the joint under local anesthesia In cases of marked effusion, the needle is detached from the syringe, sterile forceps or a hemostat being used, and the fluid is permitted to drain through the needle.

FIG. 410. Forced abduction of the leg or forced adduction of the knee may cause the injuries shown in b, c and d. (a) Normal ligament arrangement. (b) Rupture of the internal lateral ligament. (c) Fracture of the external tuberosity of the tibia. (d) Splitting fracture of the external tuberosity, rupture of the internal lateral ligament and rupture of the anterior crucial ligament.



roentgenograms show calcification along the tender area. This may be a form of the condition known as Pellegrini-Stieda disease.

Diagnosis. The diagnosis is based on the history of injury followed by pain and disability at the knee. The patient limps or is unable to bear any weight on the knee. Muscle spasm maintaining slight flexion suggests a cartilage injury, but the flexion spasm subsides on gentle extension and on procaine injection into the painful area. Effusion into the joint, localized tenderness of the medial side of the knee and pain on forced abduction of the leg usually are present. When the ligament is ruptured, it is possible sometimes to abduct the leg beyond the normal limit (Fig. 411). Ligament injuries often accompany other injuries to the knee.

Treatment. Preliminary treatment is given as described on page 553. In addition, infiltration of the acutely painful area with procaine solution, from 20 to 30 cc. of 1 per cent, gives almost immediate relief of pain and muscle spasm. Repeated aspiration of the joint may be necessary. When the injury is mild, the splint and the pressure dressing or strapping are continued for from 7 to 14 days, or until the local tenderness subsides. Additional injections of procaine are helpful for persistent pain.

When the injury is severe and actual rupture of the ligament is present, the immobilization must be prolonged to obtain firm healing. After preliminary treatment and inspection of the roentgenogram, the knee is immobilized. This may be accomplished in several ways. Adhesive strapping and bandage are unsatisfactory, and even splinting is inferior to the immediate rigid immobilization obtained from casts.

Usually, a gelatin boot is applied from the toes to the knee. This is overlaid by a plaster cast (shown in Figs. 619 and 620), but with the knee

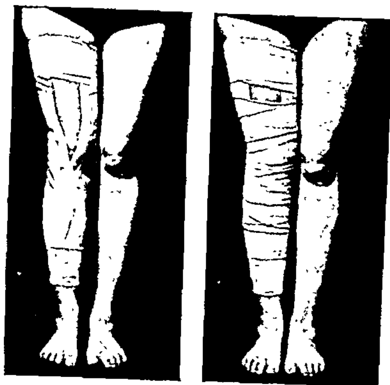


FIG. 409. (*Left*) Adhesive strapping for the early treatment of acute traumatic synovitis of the knee joint. After aspiration of the effusion, a crisscross strapping of 2-in. adhesive is applied. It is begun well laterally and as high as possible on the thigh, and extends downward across the lower leg at the knee. Several succeeding layers are applied. The straps are anchored above and below by circular elastic bandage (*Right*) The strapping is completed by the application of a firm elastic bandage at the knee. (Ferguson, L. Kraeer, and Thompson, Wesley D.: Ann Surg 112 451)

able. In the author's experience, it has been performed safely as occasion arose without untoward results.

ACUTE TRAUMATIC SYNOVITIS

Following an injury to the knee, there may be moderate pain on motion and serous or serosanguineous effusion into the joint. When no definite evidence of bone, ligament or cartilage injury can be demonstrated clinically or roentgenographically, it is assumed that the synovium mainly has been injured.

Treatment. In these instances, preliminary treatment of the knee (p. 553) is given. The splint and the pressure dressing are used until pain and swelling have subsided. Instead of the splint, an adhesive strapping and a pressure bandage often are sufficient to hold the knee in extension (Fig. 409). The splint or the adhesive is removed after about 2 weeks, and the elastic pressure bandage is continued for a week or two longer. Residual stiffness is relieved by heat and massage.

INJURIES TO THE LATERAL LIGAMENTS

INTERNAL LATERAL LIGAMENT INJURIES

Etiology. Injury to the internal lateral ligament usually is caused by abrupt forced adduction of the knee while the leg is fixed, or there is sudden internal rotation of the thigh upon the fixed leg (Fig. 410). The ligament tears through its substance or at its tibial or femoral attachment. The lacerations may be either very slight or very extensive. At the femoral attachment, the laceration may include a portion of the periosteum and the bone into which the ligament inserts Periosteal injury is manifested later by thickening and persistent tenderness at the medial side of the medial condyle, and, in a few weeks,

When a diagnosis of rupture of the ligament is made, the knee is immobilized as described above.

INJURIES TO THE SEMILUNAR CARTILAGES

Etiology. Injuries to the semilunar cartilages are the most common derangements of the knee joint. The internal semilunar cartilage is less mobile and is injured much more often than is the external. The cartilages are dislocated or torn, the laceration being longitudinal or in the anterior or the posterior portion. Bristow[2] has shown that injury to the internal cartilage occurs when the knee is flexed partially and bearing weight, and when there is internal rotation of the femur on the tibia, which is fixed by the foot on the ground, or floor. Injury to the internal lateral ligament also follows this violence. Less often, other forms of violence cause cartilage injuries. When a thick portion of the cartilage slips between the femoral condyle and the tibia, the knee locks and cannot be extended fully.

Diagnosis. A history of the typical violence followed by a sensation of "something snapping" or "something giving way" in the joint is usually obtained. There is severe pain, and often there is a typical locking of the joint. The diagnosis is simple if the patient's knee is locked at the time of the examination. Or he may describe manipulation of the locked leg by a friend or a bystander that was followed immediately by (1) relief of the acute pain and (2) ability to extend the knee. Later the knee becomes swollen, stiff and increasingly painful.

Examination may disclose a typical locking of the knee, with ability to flex it but an inability to extend it more than 150° to 160°. If the locking has been reduced prior to examination, there may be only effusion in the joint, acute tenderness at the anteromedial margin of the internal tibial tuberosity and pain on motion. Other injuries to the knee often complicate cartilage lesions.

Treatment. The effusion is aspirated, and if locking is present, it is reduced immediately. Anesthesia is not always necessary, but procaine solution, 10 cc. of 1 per cent, may be infiltrated at the site of the acute tenderness. In some instances, general anesthesia is needed. With the patient seated on a table so that the legs hang freely over the edge, downward traction is made on the ankle, and the leg is abducted, rotated externally and extended rapidly. When the cartilage slips into place, the knee can be extended as fully as the uninjured one.

When reduction has been obtained or when the patient gives the typical history and local signs of cartilage injury without locking, the knee must be immobilized for a prolonged period to obtain good healing and to avoid recurrence. A gelatin boot and a posterior splint (Fig. 619) or a cast (Fig. 620) are applied, the medial border of the heel is wedged up ⅛ to $\frac{3}{16}$ of an inch, and the patient is permitted to use the leg. An elastic bandage is wrapped about the knee if the posterior splint is used. The immobilization is continued for from 4 to 6 weeks. The after-treatment is similar to that for lateral ligament injuries.

Recurrent Dislocation. Aside from a repetition of the violence to the knee (as in football), the most common cause of recurrent dislocation is poor healing of the cartilage. Repeated dislocation requires excision of the cartilage, otherwise chronic joint changes take place.

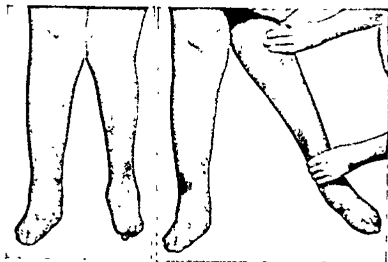


FIG. 411. An old neglected rupture of the left internal lateral ligament. The leg can be abducted widely at the knee.

flexed from 5° to 10°. Care must be taken to incorporate a felt pad the size of the hand over the head of the fibula and another over the medial side of the knee. A strip of felt is placed at the ankle and another at the upper end of the thigh. These prevent pressure from the ends of the cast. The patient uses crutches for a few days; then he goes about without them. After 4 weeks, the entire dressing is removed, a new gelatin boot and an elastic bandage are applied, and the medial border of the heel is elevated from 1/8 to 3/16 of an inch. These are continued for from 2 to 3 weeks. Home baking and massage twice daily are prescribed after removal of the gelatin boot.

Prognosis. The prognosis varies with the severity of the injury. If treatment is adequate and no other knee injuries have occurred, a satisfactory result may be expected.

External Lateral Ligament Injuries

The external lateral ligament sustains an injury much less often than the internal. The etiology, the diagnosis and the treatment of this injury are analogous to those described for internal lateral ligament injuries.

SPRAINS OF THE KNEE

Leriche's Method of Treatment.[6] Leriche advises thorough infiltration with procaine solution of the injured ligament to abolish pain and muscle spasm. This permits testing of the mobility of the joint. If the leg can be abducted on the thigh beyond the normal limit, a diagnosis of rupture of the internal lateral ligament is made. This can be verified by making a roentgenogram with the leg abducted; widening of the joint space can be demonstrated when the ligament is ruptured.

When these two signs of rupture cannot be demonstrated, Leriche diagnoses the injury as a sprain. These two conditions otherwise present the same clinical picture of pain, disability, local swelling and tenderness. In sprains, the diagnostic infiltration of procaine abolishes the symptoms completely, and the patient is advised to continue full use of the knee, even though the symptoms recur after a few hours. Often they do not recur, but, when they do, additional injections of procaine are given at intervals of 1 or 2 days. Usually, only 2 or 3 injections are required. No splint or strapping is used.

examiner places his hand on the back of the leg below the flexed knee and presses the tibia forward. If the anterior crucial ligament is torn, the tibia can be displaced forward (Fig 401B). Roentgen examination is indicated.

Treatment. Prolonged immobilization is necessary to obtain good union of the torn ligament Preliminary treatment of the knee (p. 553) is carried out. Repeated aspiration may be necessary. The splint, the pressure dressing, rest and elevation are continued until the swelling subsides. A gelatin boot (p. 599) and a plaster cast are applied (Fig. 620) with the knee in 15° of flexion. The medial borders of the heels are elevated 1/8 to 3/16 of an inch The patient is permitted to use crutches at first, later walking without them. The cast is worn for from 2 to 3 months. When it is removed, a new gelatin boot is applied from the toes to the knee, and an elastic bandage is wrapped about the knee. If the knee seems to be at all unstable, a knee brace is worn for 6 months.

Posterior Crucial Ligament Injuries

Etiology. The posterior crucial ligament, which runs upward, forward and inward, prevents posterior displacement of the tibia on the femur. Injury, which is rare, is caused by hyperflexion or by the tibia's being driven backward with the knee flexed. The rupture occurs through the substance of the ligament or at the femoral or the tibial attachment. Both crucial ligaments may be torn at the same time, usually this is associated with dislocation of the knee.

Diagnosis. The patient is seated on a table with the knee flexed at a right angle and the foot on the table. The integrity of the posterior crucial ligament is determined by pressing the tibia backward; when this is possible, the posterior crucial ligament is ruptured. (Fig. 401B)

Treatment. The treatment is as described for injury of the anterior crucial ligament (see above), except that the knee is kept fully extended.

FRACTURES OF THE SPINE OF THE TIBIA

Etiology. The spine of the tibia or its two small eminences may be fractured by the same force that causes injury to the crucial ligaments or by a lateral shearing motion of the femoral condyles The fragments may lie in good position, or they may be so displaced as to cause interference with motion of the knee. (Fig. 412)

Diagnosis. There is evidence of a severe injury to the knee joint. When there is increased anteroposterior mobility of the joint, which indicates injury to the crucial ligaments, a roentgen examination must be made to demonstrate the presence or the absence of a fracture of the tibial spine. In some cases, there is severe but ill-defined pain associated with abrupt limitation of both active and passive extension of the joint, indicating that a fragment is blocking motion. This differs from the locking associated with dislocation of a semilunar cartilage, which has an elastic and a less abrupt quality. The pain of cartilage injury usually is localized over the injured side. Cartilage injury and fracture may occur simultaneously.

Treatment. When motion is obstructed, reduction is performed after the joint is aspirated. Under general anesthesia, the knee is flexed, traction is made on the leg, and the leg is rotated from side to side as the knee is extended. If necessary, this may be

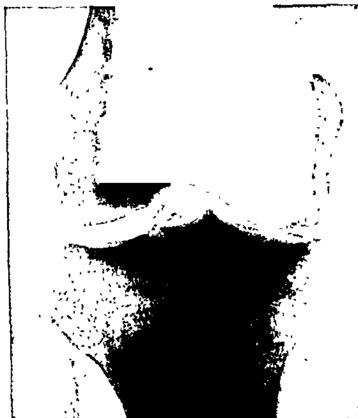


FIG. 412. Fracture of the spine of the tibia at the insertion of the posterior crucial ligament. There also was a tear of the internal lateral ligament. With conservative treatment as described (p. 563), this patient played varsity football 10 months later.

Prognosis. It is questionable whether or not true cartilage tears ever heal, even with adequate early therapy. If there is persistent pain or disability, arthrotomy may be indicated. The patient should be informed that the dislocation is likely to recur, and that in that event operation may be necessary.

INJURIES TO THE CRUCIAL LIGAMENTS

Anterior Crucial Ligament Injuries

Etiology. The anterior crucial ligament, which runs from in front upward, backward and outward, prevents anterior displacement of the tibia on the femur. It is a factor also in preventing abduction of the tibia on the femur and, to some extent, in preventing internal rotation of the tibia. Injury to the ligament may occur when the normal range of any of these motions is exceeded greatly, as in forcible hyperextension. It is likely to occur when the internal lateral ligament is lacerated extensively, and when there has been a dislocation of the internal semilunar cartilage. Rupture of a crucial ligament is very rare without other knee injuries.

The site of the injury, or rupture, of the ligament varies. It may be through the substance of the ligament or at the femoral or the tibial attachment. The latter is manifested as an avulsion of the spine of the tibia. (Fig. 412)

Diagnosis. Severe injury to the knee is evident, possibly rupture of the internal lateral ligament. To test the crucial ligaments, the patient is seated on a table with the knee flexed at a right angle and the foot on the table. The

roentgen films as lipping. The disease is uncommon in men.

Diagnosis. At first, the patient notices the pain at the inner side of the knee after she has stood or walked for a long time, then after a shorter period of effort, and, finally, at every step. It is worse when going downhill. In the late stages, it is not relieved by rest. In the early stages, the patient shows some flattening of the feet and stands so that the patellas are rotated outward. Later, induration and thickening are seen along the hamstring tendons which insert on the inner side of the knee. The anteromedial aspect of the knee is tender. Roentgen examination discloses elongation and sharpening of the tibial spines and sometimes bony proliferations (lipping) at the margins of the joint (Fig. 411). Finally, the whole joint becomes indurated and tender, and the thickening of the inner hamstrings becomes quite marked. Extension is incomplete, due to a flexion contracture of from 5° to 10°, and the lateral mobility of the patella is restricted, even with the quadriceps relaxed. The lower leg may be swollen slightly. The feet are flat, and the forefoot is supinated and abducted. The knee joint often exhibits striking changes in the films. In many of these patients, who are treated for arthritis of the knees, from 50 to 90 per cent of the symptoms come from the chronic muscle strain associated with flatfeet. Hence, even advanced arthritic changes seen in the roentgen films do not exclude this condition.

Treatment. Since the basic cause of this condition is constant strain on the knee, it is necessary to relieve the strain. A gelatin boot (p. 599) is applied with the heel supinated and the forefoot pronated. After the first layer of gelatin paste has been applied, a strip of gauze is started on the outer side of the heel, carried beneath the heel and brought up with tension on the medial side of the leg. A second strip is started on the medial side of the foot at the distal end of the first metatarsal, carried beneath the foot to the outer side of the ankle and brought up with tension on the outer side of the leg. The regular layer of gauze bandage then is applied. The entire process is repeated twice to make a 3 layer gelatin boot. The medial border of the heel is elevated from $\frac{1}{8}$ to $\frac{3}{16}$ of an inch, and a moderately elevated arch support is placed in the shoe. An elastic bandage is applied about the knee; it is worn during the day and removed at night. The gelatin boot may become loose in a few days as the swelling subsides, in which case a new one is applied. A good substitute for a gelatin boot is an ankle strapping applied to hold the foot in inversion (Fig. 117); it is covered by an elastic adhesive bandage that extends from the instep to just below the knee.

Procaine infiltration of the most tender areas about the knee is of considerable value in relieving severe pain. It may be repeated several times if necessary. A regimen should be prescribed to reduce excessive weight. As a rule, the patient's symptoms improve rapidly, and within 1 to 3 weeks the gait is almost normal. The gelatin boot is continued for from 1 to 3 months or longer, and a suitable arch support is worn permanently. Diathermy and other local physiotherapy are of little value in this condition unless the chronic strain is relieved.

LOOSE BODIES IN THE KNEE JOINT

Symptoms. Loose bodies, which are called joint mice, may be present in



FIG 413 Chronically painful knees. Two views of the same patient (*left* and *center*). Note the marked thickening, the outlines of the patellas on the skin and the flexion contracture shown in the lateral view. (*Right*) Illustrates the common combination of flatfeet, ankle pronation, chronic knee strain and varicose veins Treatment of the varicose veins without attention to the faulty weight-bearing will not give the patient relief. Adhesive marks the site of a procaine injection.

repeated several times, but, if full extension cannot be obtained, operation is indicated.

After the displacement has been reduced, or when displacement and limitation of motion have not occurred, the preliminary treatment of the knee (p. 553) may be given, or, even better, the cast described for injuries to the lateral ligaments (p. 559 and Fig. 620) may be applied immediately. The patient may walk from the beginning if there is no complication. After from 4 to 6 weeks, the cast or the splint is removed, a gelatin boot is applied, and an elastic bandage is wrapped about the knee. After immobilization is discontinued, heat and massage help to restore full function.

CHRONICALLY PAINFUL KNEES

Etiology. Many short heavy women over 40 years of age complain of pain at the inner side of the knee. The condition occurs about the time of the menopause, but Böhler[1] regards it as occurring in women of a certain constitutional type because of an increase in weight due to changes in ovulation. At this time, the muscles become weaker, the weight increases, and the arches of the feet drop. The result is an inward rotation of the leg, a slight shortening of the internal rotator muscles attached to the medial side of the tibia and a slight flexion contracture (Fig. 413). The outward rotation of the tibia necessary for complete extension is no longer possible. The internal semilunar cartilage is overloaded and becomes painful. Finally, the whole joint becomes inflamed and thickened. As a result of chronic strain, there is bony proliferation at the attachments of ligaments and muscles; this is visible in the

the knee joint. Their presence is suspected when a patient complains of repeated sudden and severe pain in the joint without having sustained an injury immediately prior to each attack. Characteristically, brief locking of the joint is associated with each pain. The joint may unlock spontaneously in a moment or two, or the patient may unlock it by manipulating the knee. Later, effusion into the joint and swelling occur.

Etiology. The joint mice may be bony, cartilaginous or fibrous. They originate from detached portions of joint cartilage, as in osteochondritis dissecans, from hypertrophied synovium and from organized blood clot. They may or may not be visible in the roentgenogram.

Treatment. The loose bodies must be removed by operation to relieve the condition.

PELLEGRINI-STIEDA DISEASE

Etiology and Diagnosis. Following an injury to the ligaments or the muscle insertions at the medial side of the knee, there may be persistent tenderness and thickening over the inner condyle of the femur. Roentgen examination may disclose a crescent-shaped calcification close to the inner condyle in the region of the adductor tubercle. This condition is a traumatic calcification in the ligaments, it may or may not be due to stripping of periosteum, and it is known as Pellegrini-Stieda disease. (Fig. 415) Nachlas and Olpp[9] point out that usually the pain and the associated symptoms are due to pathologic lesions within the knee joint, that is, arthritis or joint mice, rather than to the calcification itself. Careful search for intra-articular lesions is necessary in these cases.

Treatment. Rest and prevention of chronic strain are required. Elevation of the medial side of the heel from $\frac{1}{8}$ to $\frac{3}{16}$ of an inch relieves strain on that side of the knee. An elastic knee support or an elastic bandage immobilizes the joint to some extent and reduces edema. Physiotherapy is used cautiously, if at all.

Excessive exertion involving the knee must be avoided until all local tenderness and discomfort have subsided.

INJURY AND HYPERTROPHY OF THE INFRAPATELLAR FAT PAD

Etiology. The infrapatellar, or subpatellar, fat pad fills the space inside the capsule of the knee joint just beneath the patellar ligament. It is bruised frequently and becomes edematous. Repeated injuries produce permanent hypertrophy due to fibrosis. When the fat pad is enlarged, it may be pinched between the bones of the knee in extension.

Diagnosis. Following sudden hyperextension of the knee or direct pressure below the knee, the patient complains of pain beneath the patella and the patellar ligament, especially on going up or down stairs. On examination, an elastic and a rather tender fullness of the tissues is found on both sides of the patellar ligament. An effusion into the joint may be present. Full extension of the knee causes pain that is localized beneath the patellar ligament and often is impossible because of the edematous mass of synovium in the infrapatellar space (Fig. 416).

Treatment. If the symptoms are acute, the preliminary treatment of the knee (p. 553) is given. If full extension causes marked discomfort,



Fig. 414 (*Left*). Roentgenogram of the patent shown in Fig. 413 There are multiple bony proliferations and sharpening of the tibial spines.

Fig. 415 (*Right*). Pellegrini-Stieda disease. Extensive calcification is present along the line of the internal lateral ligament.

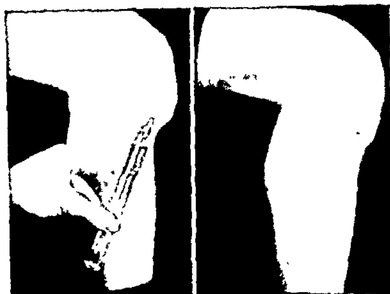


FIG. 418. Aspiration of bloody fluid from a prepatellar bursa and appearance following aspiration.

position over the knee, usually distal to the patella and over the infrapatellar tendon (Fig. 417). The bursa becomes thickened, due to chronic inflammation and trauma. Often it is made prominent due to effusion. Appearing most often in those who work upon the knees, this lesion is commonly called housemaid's knee and is considered to be an occupational disease.

Symptoms. The bursa gives symptoms when, due to some recent trauma, it becomes filled with bloody or serous effusion. It then presents itself as a swelling in front of the knee below the patella, usually without marked pain or tenderness. There is little tendency for the fluid to absorb spontaneously.

Treatment. Under local anesthesia, the fluid may be aspirated (Fig. 418); it is bloody if there has been recent trauma, straw colored if the bursitis is of some duration. After aspiration, movable bodies representing villi and straps across the bursa may be palpated. These are tender upon pressure. Simple aspiration results usually in a reaccumulation of the fluid in a few days. However, these bursae may be treated very successfully by injecting, after aspiration any one of several sclerosing solutions, such as Carabba's solution (see p. 17). Usually, about 1 to 1.5 cc. is used. Following the injection, there is an inflammatory reaction in the bursa for several days, and perhaps there will be a reaccumulation of some of the fluid. After 4 or 5 days, a second aspiration and injection may be performed. Eventually, the bursa becomes obliterated and forms a scar in the subcutaneous tissue; this is not painful (Fig. 130).

The bursa may be obliterated by a subcutaneous incision of the roof from the floor of the bursa, as described in Figure 131. The operation may be performed under local anesthesia. A firm elastic bandage should be kept on the knee for from 10 to 14 days.

The bursa may be excised under local anesthesia and the wound sutured. A flap usually is turned so that the scar does not lie directly over the knee. The area is dressed with a pressure bandage, a rubber sponge and a posterior splint usually being employed.



FIG. 416. Limited extension in hypertrophy of the infrapatellar fat pad. (Ferguson, L. Kracer, and Thompson, Wesley D.: Ann. Surg. 112:151)

from 5° to 10° of flexion may be allowed. Repeated procaine injections into the tender areas are helpful. After the acute symptoms subside, an elastic knee support or a bandage is applied (Fig. 109). When the symptoms are persistent in spite of treatment, excision of the fat pad must be considered.

VILLOUS ARTHRITIS OF THE KNEE

Hypertrophy of the subsynovial fat pads may occur in other parts of the knee joint as well as in the infrapatellar area. These hypertrophic areas extend into the joint space, and they may be pinched between the femur and the tibia. When pinching occurs, there is a sudden pain in the knee accompanied by momentary locking or by a sensation of "giving way." Later, there is effusion into the joint. Repetition of this process causes a chronic inflammatory condition of the synovial lining with further hypertrophy. This condition is called villous arthritis. Operation is indicated when symptoms are troublesome.

PREPATELLAR BURSITIS

Etiology. The prepatellar bursa is one of the adventitious bursae found commonly. It lies in a subcutaneous



FIG. 417. *Prepatellar bursitis. This was a chronically inflamed bursa with thick walls. Note the position of the bursa, not over the patella but below it, in the region of the infrapatellar ligament.*

is not on his feet or when he is standing with the foot dorsiflexed, at which time the protrusion may disappear entirely. In thin people, it may be possible to palpate the fascial rings through which the hernia protrudes. (Fig. 419)

Treatment. Pain and disfigurement are the usual reasons for therapy in this type of hernia. If the pain is believed to be due to pressure on a nerve at the site through which the hernia protrudes, it is probable that a plastic operation is the best method of therapy.

Under local anesthesia, the hernial opening is exposed; the nerve is found emerging through the deep fascia at the lowermost portion of the hernial opening. In several such cases, the author has enlarged the opening downward so as to have the nerve emerge through a new opening, the fascial defects then are closed by suture. It is necessary sometimes to perform a fascial transplant, removing a portion of the fascia lata and suturing it in the hernial opening. The wounds are closed, and a firm elastic adhesive bandage is applied. Crutches are provided so as to prevent weight bearing on the foot for a period of about 3 weeks.

Schmier[14] reported a case of fascial hernias of both legs which he treated by the injection of sodium morrhuate. This set up a local inflammatory reaction which prevented, at least in part, the protrusion of the muscle through the hernial orifice. The author has treated several cases by this method, using either sodium psylliate (Sylnasol) or sodium morrhuate This gives relief of pain, but it is questionable whether it is likely to be permanent.

PERITENDINITIS CREPITANS

(Traumatic Tenosynovitis)

Etiology and Symptoms. This lesion is described in some detail in the chapter on the hand and the fingers (p. 525). It occurs also in the muscles of the legs, and frequently follows prolonged muscular effort to which the individual is unaccustomed, as, for instance, tramping, hiking or dancing; or it occurs with use following trauma. The symptoms are similar to those described for the so-called traumatic tenosynovitis of the forearm: pain on use of the involved muscles, swelling and crepitation during muscle function.

Treatment. With adequate splinting the pathologic changes present in peritendinitis crepitans subside, and the symptoms disappear. In the lower extremity, plaster splints usually are necessary

RUPTURE OF THE PLANTARIS MUSCLE

(Tennis Leg)

Anatomy. The plantaris is a small spindle-shaped muscle that arises on the posterior surface of the femur just above the outer condyle and medial to the lateral head of the gastrocnemius. It passes downward with a long tendon between the gastrocnemius and the soleus to insert in the Achilles tendon.

Etiology. This muscle is one of the most frequently ruptured of all the muscles of the body, and it is ruptured far more often than the other muscles in the leg. Its function is to extend the foot, and it is injured most often during those activities in which the knee is extended and the foot is plantar-flexed. The patient coming



FIG. 419. Post-traumatic muscle hernia due to shrapnel injury. Note the prominence of the muscle bulge when the patient stands on his toes and the depression when the weight is borne on his heels (Official U. S. Navy photograph)

Infection of a prepatellar bursa occasionally follows a furunculosis over the knee. In furunculosis the area becomes tender and swollen, with marked redness. If a posterior splint is applied to immobilize the knee and hot moist dressings are used for 2 or 3 days, the infection usually localizes and points, as does any furuncle or carbuncle. As a rule, further progress of the infection can be prevented by appropriate antibiotic (penicillin) administration. Frequently, however, by contiguity the infection may involve the underlying prepatellar bursa, in which case adequate incision and drainage are necessary and may be carried out under local infiltration anesthesia through a transverse incision. The wound is packed with plain or iodoform gauze, and a posterior splint is applied. With hot moist dressings, splinting, elevation and antibiotics, infection usually subsides, and healing occurs as with the uncomplicated furuncle.

MUSCLE-SHEATH HERNIAS

Muscle-sheath hernias appear as small protrusions on the leg. They may or may not be associated with varicose veins, and often they are mistaken for the bulges of varicosities Frequently they are extremely painful.

Etiology. Either these lesions are congenital or they are traumatic openings in the deep fascia of the leg through which the underlying muscle protrudes. When they occur without any previous history of trauma, they are located often where the nerves perforate the deep fascia to become subcutaneous. The nerves involved most frequently are the sural and the superficial peroneal nerves on the lateral aspect of the leg.

Diagnosis. A muscle hernia is distinguished easily from varicose veins by the fact that it protrudes when the patient is standing and becomes even larger when he is standing on his toes. It is less prominent when the patient

is not on his feet or when he is standing with the foot dorsiflexed, at which time the protrusion may disappear entirely. In thin people, it may be possible to palpate the fascial rings through which the hernia protrudes. (Fig. 119)

Treatment. Pain and disfigurement are the usual reasons for therapy in this type of hernia. If the pain is believed to be due to pressure on a nerve at the site through which the hernia protrudes, it is probable that a plastic operation is the best method of therapy.

Under local anesthesia, the hernial opening is exposed; the nerve is found emerging through the deep fascia at the lowermost portion of the hernial opening. In several such cases, the author has enlarged the opening downward so as to have the nerve emerge through a new opening; the fascial defects then are closed by suture. It is necessary sometimes to perform a fascial transplant, removing a portion of the fascia lata and suturing it in the hernial opening. The wounds are closed, and a firm elastic adhesive bandage is applied. Crutches are provided so as to prevent weight bearing on the foot for a period of about 3 weeks.

Schmier[14] reported a case of fascial hernias of both legs which he treated by the injection of sodium morrhuate. This set up a local inflammatory reaction which prevented, at least in part, the protrusion of the muscle through the hernial orifice. The author has treated several cases by this method, using either sodium psylliate (Sylnasol) or sodium morrhuate. This gives relief of pain, but it is questionable whether it is likely to be permanent.

PERITENDINITIS CREPITANS

(Traumatic Tenosynovitis)

Etiology and Symptoms. This lesion is described in some detail in the chapter on the hand and the fingers (p. 525). It occurs also in the muscles of the legs, and frequently follows prolonged muscular effort to which the individual is unaccustomed, as, for instance, tramping, hiking or dancing; or it occurs with use following trauma. The symptoms are similar to those described for the so called traumatic tenosynovitis of the forearm: pain on use of the involved muscles, swelling and crepitation during muscle function.

Treatment. With adequate splinting the pathologic changes present in peritendinitis crepitans subside, and the symptoms disappear. In the lower extremity, plaster splints usually are necessary.

RUPTURE OF THE PLANTARIS MUSCLE

(Tennis Leg)

Anatomy. The plantaris is a small spindle-shaped muscle that arises on the posterior surface of the femur just above the outer condyle and medial to the lateral head of the gastrocnemius. It passes downward with a long tendon between the gastrocnemius and the soleus to insert in the Achilles tendon.

Etiology. This muscle is one of the most frequently ruptured of all the muscles of the body, and it is ruptured far more often than the other muscles in the leg. Its function is to extend the foot, and it is injured most often during those activities in which the knee is extended and the foot is plantar-flexed. The patient coming



Fig. 420 Osgood Schlatter's disease This appeared typically in a young boy as a painful swelling at the tibial tubercle

down on the hyperextended foot in tennis is a typical example of the injury that produces this rupture.

Symptoms. The symptoms produced by this lesion are quite typical. The patient experiences a sudden acute pain in the calf of the leg; often this is associated with a snap that is audible to both the patient and those about him. The pain is so sudden and knifelike that the patient turns to see who has thrown a stone or stuck a knife in his leg. Pain and weakness in the leg become so severe that it is necessary for him to discontinue his activities, and soon there is a painful swelling of the calf.

Diagnosis. Examination shows definite swelling and tenseness of the calf with tenderness, especially at the site of the muscle rupture, which usually is at the musculotendinous junction The most distinctive and diagnostic symptom is pain when the muscle is used against resistance. This is demonstrated by asking the patient to plantar-flex the foot while the examiner's hand is placed to resist this motion. As time goes on, a definite ecchymosis begins to appear in the lower part of the leg and extends down to the foot.

Treatment. Almost immediate relief of symptoms may be obtained by the application of a firm supporting bandage or dressing. Two such dressings are available. The easier to apply is one of elastic adhesive, begun at the foot and carried as a spiral bandage up the leg to the knee. However, when there is marked swelling, the dressing that gives more support is the Unna paste boot (p. 599). The patient may remain ambulatory throughout the treatment with either dressing, which should be continued for 3 or 4 weeks at least. Active function with support gives much more comfort and earlier relief of symptoms than does conservative therapy with rest, diathermy and other measures.

OSGOOD-SCHLATTER'S DISEASE

This is a painful enlargement of the tibial tubercle during the years of puberty (Fig. 420). It is seen more often in boys than in girls, and is characterized by an enlargement of the tibial tubercle with some pain, especially on extension of the lower leg on the thigh against resistance. Frequently there is a history of direct or indirect trauma, such as kicking a football.

Pathology. Cole[3] made a study of this disease, he believes that it occurs as a result of rapid growth during adolescence, during which period the quadriceps muscles are placed under

a great physiologic strain. This produces changes within the infrapatellar tendon due to alterations of the blood supply in the tendon: microscopic section demonstrates fibrocartilaginous areas in the tendon which later become calcified and ossified. Cole believes that the disability experienced by patients with this disease is due to an increase in intratendinous pressure. As time goes on, if conservative treatment is instituted, the peritendon adapts itself to the increased size of the tendon, and eventually the disability and pain disappear. The enlargement of the tissues in the region of the tibial tubercle is associated with bony changes in this area, and lateral roentgenograms show progressive changes in calcification in the region of the epiphysis of the tibial tubercle. Cole believes that these changes occur in the tendinous insertion of the quadriceps extensor muscle, and that the calcified and the ossified islands appearing in the film occur really in the tendinous tissue rather than in the epiphysis.

Treatment. Since this disease is self-limiting, conservative therapy by means of supportive strappings to relax the quadriceps muscle and the tendon is the treatment of choice. Crisscross strapping, extending from the lateral surface of the thigh downward and across the front of the leg to hold it in extension, plus a firm elastic bandage at the knee, usually give sufficient support (Fig. 409). This must be maintained for a period of several weeks, sometimes as long as 5 or 6 weeks, but invariably the condition gradually subsides spontaneously without other therapy. Casts or splints usually are not necessary, and no form of physiotherapy seems to be of any value.

VARICOSE VEINS

The abnormal enlargement of the veins is spoken of as varices or varicosities. These are seen most commonly in the lower extremities, and it is here that they produce symptoms of disability.

Anatomy. To understand the pathology and the treatment of varicose veins, it is important to recall the anatomy of the veins of the leg. The venous blood is transmitted upward to the heart by two sets of veins: the deep veins, represented by the posterior tibial, the anterior tibial, the peroneal and the popliteal, which go to form the femoral vein; and the superficial veins, represented by the long and the short saphenous veins. These two venous systems are connected by communicating veins which pierce the deep fascia of the leg. (Fig. 121)

The deep veins are placed deeply in the leg. They are surrounded by muscle and fascia, which give them support. The superficial veins, however, lie in the subcutaneous fatty tissue and have relatively little support from surrounding structures. The flow of blood from the foot to the heart is maintained by several factors. From an anatomic point of view, the veins are supplied with bicuspid valves which maintain the flow of blood upward and prevent backflow so long as they are competent. Blood is moved onward by a combination of forces, which includes capillary pressure, cardiothoracic aspiration, which is produced by respiration, and especially, perhaps, the force of contracting muscles. The last-mentioned factor is known to be an important one and can be demonstrated in cases of varicose veins by noting a decrease in the size of the superficial veins following

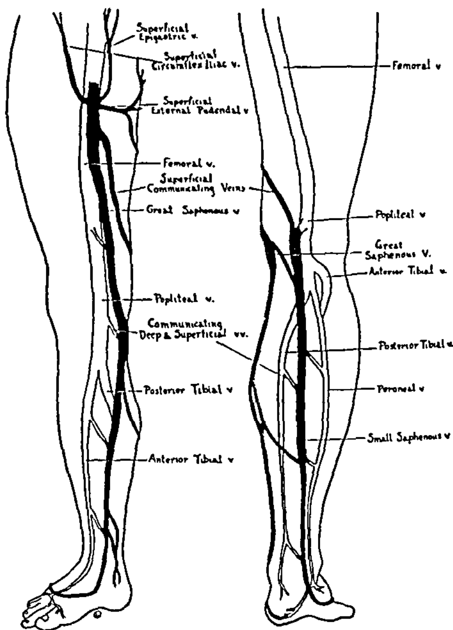


Fig. 421. Anatomy of the veins of the leg. The superficial veins are indicated in black and the deep veins in white. The great saphenous is known also as the long, or the internal saphenous, the small, as the short, or the external. (Ann. Surg. 102:304)

walking; this is caused by the drawing of blood from the superficial to the deep circulation with muscular contraction. In a general way, the flow in the superficial veins is upward, but it is probable that blood reaches the deep circulation by the shortest route and that, in large part, the flow from the superficial circulation is through the communicating veins. The direction of this flow is maintained also by bicuspid valves, which prevent back-

flow from the deep into the superficial circulation in periods of muscular relaxation.

Etiology. The superficial veins of the leg are particularly subject to dilatation, the causes of which are many. They are placed in the superficial subcutaneous areolar tissue, where they have little perivenous support. In addition, the long saphenous, because of its great length, is subject to a consequent high internal pressure. It is estimated that about 98 per cent of varicosities are of the long saphenous.

Various other factors appear to be common in the etiology of varicose veins. Unquestionably, there is a hereditary tendency. Frequently, patients volunteer the information that several members of the family have or have had varicose veins. This suggests the possibility of a weakness of the vein walls in elastic tissue. Many varicose veins appear to be occupational in origin. Prolonged standing, especially in hot rooms, may predispose to the development of varicosities. Pregnancy is a frequent cause, and it is probable that two etiologic factors play a part in these patients: one is pressure upon the veins of the pelvis by the enlarging uterus; the other is an increase in the intra-abdominal pressure. Both tend to produce a partial obstruction of the venous return with consequent dilatation of the vessels. Phlebitis, whether due to infection or to trauma, may produce a partial incompetence of the valves of the vein with subsequent dilatation of the venous segment in that region. There is no question that, as the vein dilates, more and more valves become incompetent, and, as this occurs, the veins become more dilated, so that a vicious cycle is started.

Pathologic Physiology. It is believed that usually valvular failure involves the saphenous system, but incompetence of the valves of the communicating veins also is found; this is either congenital in origin or the result of a phlebitis.

The fact should not be overlooked that dilatation of the superficial veins may be a physiologic one which is due to a block of the deep venous circulation by phlebitis. In these cases, the dilatation may be a compensatory one, but canalization of the thrombus produced by the deep phlebitis usually takes place at a later date, and the enlarged superficial veins remain then as varicosities.

Studies of the physiology of varicose veins have shown that there is definite stasis of venous blood in the dilated veins, and in the erect posture under some conditions the flow is reversed, that is, it flows toward the periphery rather than toward the heart. Studies of venous pressure in vessels with incompetent valves indicate that the pressure is extremely high, especially when there is any increase in intra-abdominal tension. In spite of the increased pressure in varicose veins, edema is not marked unless there is incompetence of the communicating veins or a deep thrombophlebitis.

Symptoms. Many varicosities give no symptoms, except disfigurement, and, especially in the spring months, patients seek medical aid to have their veins obliterated to avoid the embarrassment of unsightly legs when they appear in a bathing suit (Fig. 422). More often, however, the patient will complain of heaviness and easy fatigue in the leg involved, with slight swelling about the ankle after having been



Fig. 422. (*Left*) Unsightly veins causing relatively few symptoms. This represents a dilatation of the superficial communicating veins extending from the popliteal to the saphenous vein. (*Right*) Early stage of pigmentation and stasis dermatitis in a patient with large varicose veins.

on the feet all day. This swelling disappears during the night. Frequently, there are nocturnal cramps which waken the patient. Usually, the cramps occur in the calf of the leg and in the foot. Many female patients complain of soreness in the region of the veins only at the time of the menses, at which time, also, the veins seem to be larger.

As time goes on, various changes occur in the skin and the subcutaneous tissues which are drained by the enlarged vein. There is a brownish pigmentation, often associated with itching, and an eczematoid dermatitis which has been termed stasis dermatitis. (Figs. 422, *right*, and 423) When edema is a prominent factor, there is a gradual replacement fibrosis of the subcutaneous fatty tissue, so that a firm induration with a brawny pitting edema replaces the soft subcutaneous tissue of the leg above the ankle. In older patients, pain in the ankles and the knee joints is quite common.

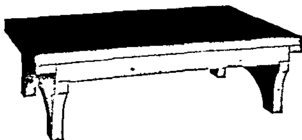
In dilatations of cutaneous vessels, often the skin over them is so thin that the veins are traumatized, with the formation of a thrombosis, which eventually may ulcerate and bleed In the erect posture, the high venous pressure permits a spurt of considerable force from the ulcerated vein. This is not dangerous, unless it is unrecognized, as may be the case if it occurs at night while the patient is in bed. Of course, it may be controlled



FIG. 423. (*Left*) Later stage of varicose veins showing marked pigmentation at the typical site in the lower inner leg in a patient with large varices.

FIG 424. (*Right*) Later stage of degenerative change in the lower leg associated with varicose veins. Note the fibrosis and relative constriction in both legs above the ankle and the ulcerations developing in the fibrotic area.

FIG. 425. Platform 12 in. high for examination of patients with varicose veins. The platform is long enough to permit the patient to stand with the legs wide apart in order that the saphenofemoral junction may be palpated easily.



easily by a firm bandage. The late and the most dreaded complication of varicose veins is the so-called varicose ulcer (Fig. 424; see also page 594). This results usually from trauma in an area in which the resistance to infection is lowered by vascular change and replacement fibrosis.

Examination of the Patient. The symptomatology of the patient with varicose veins does not always give a clear picture of the type of veins to be found. Disfigurement may be due to enlarged venous radicals or to numerous small cutaneous varices in the thigh and the leg. Pain as a symptom may be due to edema or chronic phlebitis or to simple distention of a dilated burst of cutaneous vessels within the skin.

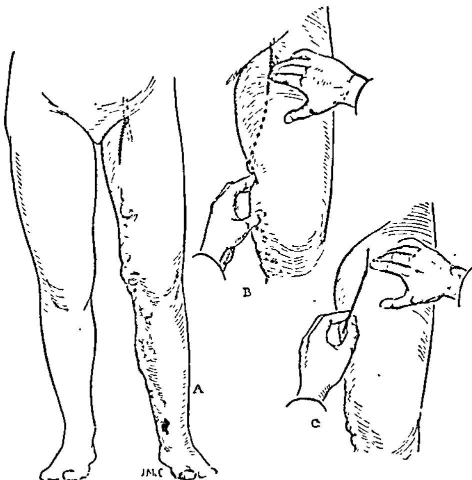


FIG. 426. The Schwartz, or percussion, test. (A) The patient stands with the weight distributed equally on both feet. (B) For the examination of the left leg, the right hand is placed in the region of the groin, and, with the left hand, the vein is percussed gently. A percussion wave, palpated at the upper portion of the saphenous vein, gives the examiner an accurate idea of the location of the vein. (C) In preparing the patient for ligation, a colored antiseptic solution is used to mark the course of the vein on the skin.

For the examination, the patient should stand on a platform from 12 to 14 in. high (Fig. 425). The entire leg up to the groin is observed. Notation is made of the site, the size and the position of the veins, that is, whether cutaneous or subcutaneous, and observations are recorded as to edema, replacement fibrosis, pigmentation, ulceration and so forth.

Tests for Varicose Veins

In large varicose veins, tests for valvular incompetence are important, because the subsequent therapy depends upon the results of these tests

Schwartz, or Percussion, Test (Fig. 426). With the patient standing on a stool and the examiner sitting in front of him, one hand is placed along the inner surface of the upper thigh, and the vein in the calf is percussed or tapped gently with the fingers. In dilated veins, a wave of fluid may be palpated by the upper hand, and, by this fluid wave, the vein can be traced to the saphenous opening. This is the most accurate method of locating



FIG. 427. Trendelenburg test. The patient has been placed on the examining table and the right leg elevated to empty the blood from the superficial veins Pressure is made with the hand over the saphenous vein at its uppermost portion, and the patient is asked to stand. (*Left*) The veins are not apparent while the pressure still is maintained. (*Right*) As soon as the hand is removed, the vein fills rapidly from above. This is a positive Trendelenburg test

course of the long saphenous vein, and it is used always in determining the site of a saphenous ligation. The Schwartz test does not demonstrate necessarily incompetence of the valves of the veins, but, in the author's experience, any vein showing a positive Schwartz test has shown incompetence.

Trendelenburg Test (Fig. 427) Having located the course of the saphenous vein in the upper thigh by the Schwartz test, the area is marked or the hand is held in place and the patient is asked to lie down. Then the leg is elevated to permit the blood to drain by gravity from the dilated vein. Next, pressure is made and maintained over the saphenous opening while the patient stands. If the veins remain empty for from 30 to 35 seconds after the patient is in the erect posture and then fill up rapidly from above when the pressure is removed from the saphenous opening, the inference is that the valves of the long saphenous are incompetent and permit a backflow from the saphenofemoral junction into the saphenous vein. This is said to be a positive Trendelenburg test. If the veins fill up while pressure is maintained over the saphenofemoral junction during

the first 30 seconds after the erect posture is assumed, the inference is that blood is passing from the deep to the superficial circulation through the communicating veins, and that, therefore, the valves of the communicating veins are incompetent. If they fill also from above when pressure is removed from the saphenofemoral junction, it is understood that the valves of both the communicating veins and the long saphenous are incompetent. This is spoken of as a double-positive Trendelenburg test.

Perthes' Test. Perthes' test determines the competence of the deep circulation. A tourniquet or firm bandage is placed below the knee to block backflow in the saphenous vein from above. Walking or any other motion producing contraction and relaxation of the muscles of the leg should suck blood from the superficial into the deep circulation by the communicating veins, so that the veins below the knee are less distended if the deep circulation is competent. This test is somewhat indefinite in its practical applications, and in many cases the patients already have demonstrated competence of the deep circulation by compression of the superficial veins with elastic stockings or bandages. This has proven to be more valuable clinically than Perthes' test in estimating the competency of the deep venous circulation.

Pratt's Test for Incompetent Communicating Branches. To find incompetent communicating branches, Pratt[10] applies elastic bandages from the foot to as high as possible on the thigh and then a snug tourniquet above the bandage to compress the saphenous vein. With the patient standing, the bandage is removed slowly from above downward. "A sudden protrusion of a collection of veins shows the point of incompetence." This site should be marked on the skin By applying a second elastic bandage from above downward, the upper veins are compressed as the lower bandage is released gradually, and each incompetent perforating branch may be demonstrated accurately and marked down to the ankle. This method gives the most useful information of any test yet proposed for the demonstration of incompetent communicating veins.

Treatment of Varicose Veins

After a thorough examination of the patient, especially a study of the veins and the incompetency of their valves, a plan of therapy must be decided upon.

In large saphenous veins in which incompetency of the valves has been demonstrated, it is evident that the venous stasis and the complicating changes that are associated with it are the result of the hydrostatic pressure from above caused by the valvular incompetency. For a time, attempts to block the vein by thrombus formation (injection) were accepted as a therapeutic method, but experience showed that canalization of the thrombus and recurrence of varicosities resulted.

Ligation of the saphenous vein and its branches at the saphenofemoral junction was performed to remove the head of hydrostatic pressure from above. This is a very essential procedure, but it did not give complete relief of venous stasis because many large veins remained Injection therapy of these veins was followed by recurrence of varices over the years.

It was realized that, in many cases, persisting venous stasis after ligation of the saphenous vein in the groin

was due to back flow caused by incompetence of the valves of the communicating veins. Multiple ligation at the site of perforators was employed to correct this abnormality. The veins that remained were thrombosed by injection. The long-term results were better from this form of treatment than from previous methods. All these methods of therapy could be carried out on ambulatory patients. By high saphenous ligation, multiple ligations and injection of remaining veins, most of the offending veins could be removed and the changes caused by venous stasis controlled. It is apparent that new veins may enlarge or injected segments canalize, hence the necessity for any patient under treatment for varicose veins to make biannual visits for injection of veins that appear.

A more complete relief of venous stasis and a more rapid and permanent result can be obtained by removal of the varicose veins by stripping after high saphenous ligation. This operation entails hospitalization for anesthesia and for several days' convalescence, but the patients are ambulatory from the first, and the removal of sutures is an office procedure.

If there is an enlargement of the lesser saphenous vein and if the Trendelenburg test, with pressure at the knee, is positive, ligation of the lesser saphenous vein is performed in the popliteal space. Whatever veins remain 3 to 6 weeks after the time of ligation are treated by injection.

Small, thin-walled varicose veins in young women, enlargement of cutaneous veins, recurrences following ligations and excisions of veins, and veins associated with arthritic pain in the ankle and the knee joint are treated by injection.

Ligation of the Saphenous at the Saphenofemoral Junction. This procedure is indicated in all cases of varicose veins in which studies indicate an incompetence of the valves of the long saphenous vein. The ligation may be performed safely in ambulatory patients, the author has performed many ligations as an office procedure.

In preparation for the operation, the patient is asked to remove his clothes and to put on a gown. The upper thigh and groin are shaved, and, with the patient standing, the course of the vein is identified by palpation and percussion. The upper portion of the vein and the saphenofemoral junction are marked by a colored solution, such as tincture of merthiolate. It is important to localize the site of the vein as well as possible, since this makes dissection easier and lessens the likelihood of trauma to fatty tissue in hunting for the vein. The patient is placed on the operating table with the leg turned outward slightly and the knee flexed a little. Males are asked to co-operate by holding the scrotum away from the field of operation with the hand opposite the side to be ligated. The field is prepared with several washings of 70 per cent alcohol.

The incision may be vertical along the course of the saphenous or transverse along the fold of the groin (Fig. 428) The line of the incision is infiltrated with 1 per cent procaine containing epinephrine. The deeper subcutaneous infiltration then is made through the cutaneous anesthetic area An incision from 1½ to 2 in. long is made through the skin, and small sharp rake retractors are introduced to permit exposure. With a curved hemostat, the fatty tissues are separated to expose the vein, which appears as a

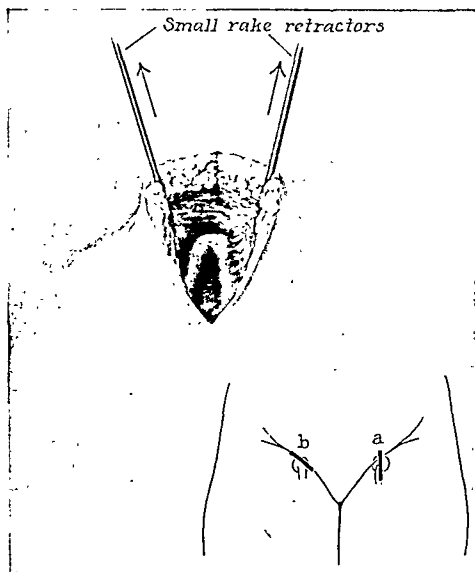


FIG 428 (*Inset*) Alternate lines of incision in the groin or along the course of the saphenous vein for a saphenofemoral ligation (*Above*) A vertical incision after division of the skin and the subcutaneous tissues. In this case, there is a large internal superficial femoral vein which is almost as large as the long saphenous itself.

bluish structure in the depth of the wound. If the marking before operation has been accurate, the dissection should come down directly upon the vein. If it is not found at first, it is probably because the incision has been placed too far laterally, and the dissection should be carried into the fatty tissues in the mesial part of the wound. The vein always is superficial to the deep fascia of the leg, and it should be found just mesial to the pulsation of the femoral artery, which is easily palpable in the wound.

When the vein has been located, the rake retractors are placed more deeply, and, with forceps and curved hemostat, its connective tissue sheath is

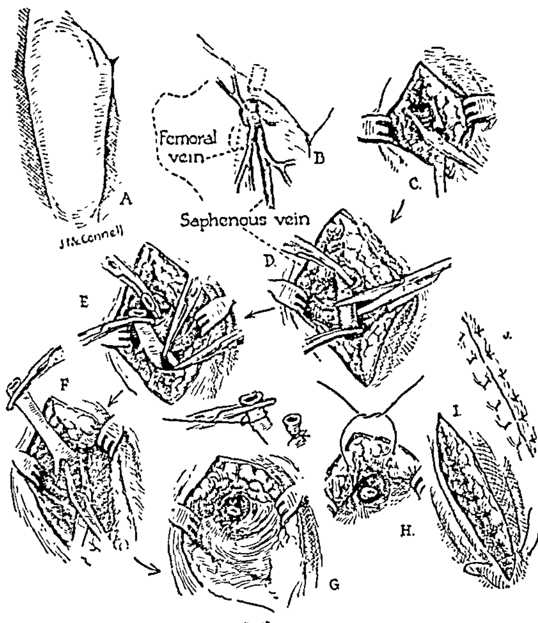


FIG. 429. Technic of ligating the saphenous vein at the saphenofemoral junction. (A) Line of incision (B) Diagrammatic drawing of the vein and its branches (C) The wound is being separated bluntly with a curved hemostat (D) The vein has been isolated and clamped with hemostats so that it may be divided with the scissors (E) The lower portion of the vein is reflected downward, whatever small vessels appear are ligated separately, and the main vein is ligated as far down as possible in the wound. (F) Attention then is turned to the upper portion of the vein, which is turned upward and dissected from below Each vessel as it appears is clamped and ligated singly (G) The saphenous is ligated doubly at its junction with the femoral vein. (H) The ends of the veins are buried with purse-string sutures (I) The wound is closed with interrupted sutures, which encircle the entire base of the wound (J) Mattress sutures of fine wire are used in the skin.

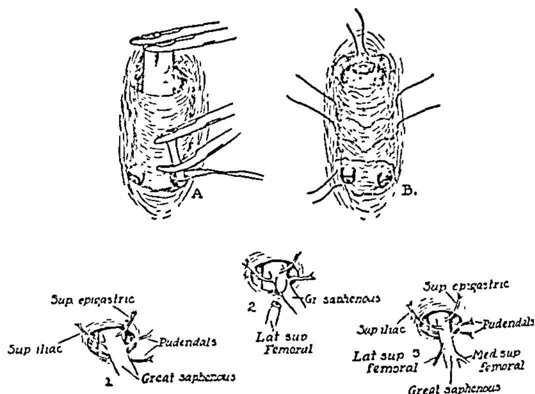


FIG. 430. (A and B) Dissection of the vein and method of suturing the base of the wound. (1, 2 and 3) Variations in the veins in the region of the saphenofemoral junction.

divided (Fig. 429). It is wise at this time to infiltrate round the vein with the anesthetic solution, because tension upon the perivenous structure sometimes gives slight discomfort. The vein then is lifted up with the forceps, and, with the curved hemostat, it is dissected away from the fatty tissue until 1 cm. or more is entirely free. Two hemostats are placed on the vein, which is divided between them with the scissors. This is one of the most important steps in the operation, because, after division of the vein, it may be placed on tension with the hemostat and turned backward upon itself, making the dissection much easier and more rapid. The distal end of the vein first is dissected free, the retractors being placed in the lower end of the wound. By pulling down upon the wound and upward upon the vein, a considerable portion of it may be exposed. With a curved hemostat placed on the vein as far down as it can be exposed, a ligature is tied about it at the site of the hemostat. A second ligature usually is placed near the first as a safety measure, and then the vein is cut off, leaving a cuff about ½ cm. long. The vein tends to retract into a cone-shaped portion of the wound from which it has been dissected.

Retractors now are placed in the upper portion of the wound. The upper part of the vein, which is in the grasp of the hemostat, is placed on tension, turned up and dissected free from the underlying connective tissue. As the dissection progresses, numerous branches are met; these are not constant by any means but usually at least two small veins are enter-

ing the upper part of the saphenous from the lateral side, two from the mesial side and one from above (Fig. 430). As each vein is encountered, it is divided between hemostats; the vein on the saphenous side of the branch is not ligated, but the free portion is tied with fine silk. With adequate retraction and downward or upward traction upon the saphenous, the entire saphenous opening may be exposed, and, after all the vessels entering its upper portion have been ligated, a curved hemostat is placed across the saphenous vein at the saphenofemoral junction, and the vein is ligated doubly at this point with silk. The vein then is divided about 1 cm. beyond the ligatures.

If the operation has been performed carefully, the wound is completely dry, and the ligated ends of the veins have retracted into a cone-shaped area at each extremity of the wound.

Wound closure is effected by fine silk sutures, which are placed from just below the skin on one side of the wound to the same point on the other, the fatty tissues being caught at the sides and in the depths of the wound. These sutures, which are placed to obliterate dead space, surround the stumps of the ligated vessel in the upper and the lower angles of the wound. Usually, the upper and the lower sutures are placed and tied first. Both middle sutures are inserted before either one is tied, otherwise it is difficult to place them accurately in the depths of the wound. The skin is closed with mattress sutures of fine alloy steel wire, usually three of them, and occasionally interrupted sutures are inserted between them.

A compression bandage is applied. Usually a 3 x 3 in. dressing folded upon itself is placed directly over the wound and then a larger dressing over it to form a pyramid of gauze, which is held in place with one or two strips of 1-in. adhesive. The patient then is asked to stand, and further compression is provided with a strip of elastic adhesive. This is started on the upper lateral surface of the thigh and brought downward just below the groin and round the leg to end upon itself on the mesial surface of the thigh. To prevent the ends of the elastic adhesive from rolling, they are secured with two strips of ordinary adhesive (Fig. 73).

The patient is allowed to dress at once and is given a prescription for 6 tablets of morphine sulfate, gr. 1/6, with instructions to take one every third hour if needed for the relief of pain. He is warned that he will have some pain about an hour after operation, that it will last for about 2 hours, and that after that he can expect some soreness in the area of the wound, which, however, should lessen each day. He is permitted to be about and is urged not to stay in bed. In our experience, patients have less discomfort and there is less likelihood of complication if they are ambulant. The patient may pursue his usual occupation unless it requires strenuous physical exertion, in which case the operation is planned so that he will have 2 or 3 days away from it.

Frequently, there is a thrombosis of the saphenous vein below the site of the ligation, characterized by a painful hard swelling along the course of the vein. The patient is warned of this possibility and instructed to return if this complication arises; the pain and the disability may be relieved easily by applying a firm elastic adhesive bandage over the vein involved.



FIG. 431. (*Left*) Large varicose vein with a positive Trendelenburg test. This vein was found to be incompetent to the saphenous opening. (*Right*) Result 6 weeks after ambulatory ligation. This vein thrombosed down to the mark on the lower leg. No injections were necessary. (Ann. Surg. 102:304)

If there are no complications, the patient is asked to return in 1 week from the day of operation, when the sutures are removed, and a simple dressing is applied, either gauze and adhesive or gauze and elastic adhesive being used. The patient removes this dressing in 4 or 5 days and is asked to return for further observation in 3 weeks, *unless pain and soreness in* the vein, indicating a subsequent thrombosis, make an earlier visit necessary.

The complications following this operation are relatively few. Many patients do not take the morphine tablets prescribed, or if they do, it is a matter of only one or two. Many of the patients volunteer the information when they appear for the removal of the sutures that the leg feels much lighter, and that the swelling and the ache have disappeared. Infection has occurred in only 1 of 200 ligations performed as an office procedure. Thrombosis of the vein below the site of ligation occurs in about 1 of every 10 patients

There have been suggestions in the literature concerning injections at the time of ligation, either into the distal stump of the vein or through a catheter inserted into its distal portion. This produces an excellent thrombosis of the distal segment of vein, but the reaction often is quite marked Many times thrombosis occurs without injection. (Figs. 431 and 432)

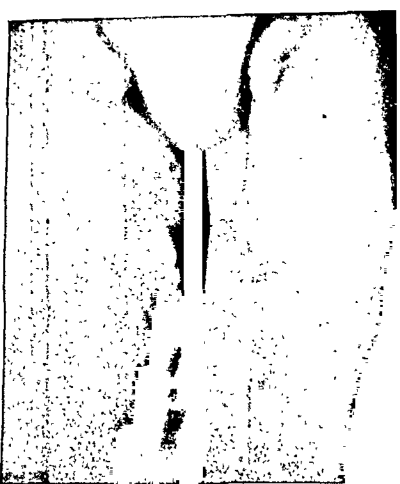



FIG. 432 (*Left*) Large dilatation of the saphenous vein with enlargement of the saphenous bulb. This patient was referred to the Varicose Vein Clinic wearing a truss for femoral hernia. (Ferguson, L. Kraeer: Am. Surg. 102:304) (*Right*) Same patient 9 months later following bilateral ligation at the saphenous bulbs. The patient was ambulatory throughout treatment.

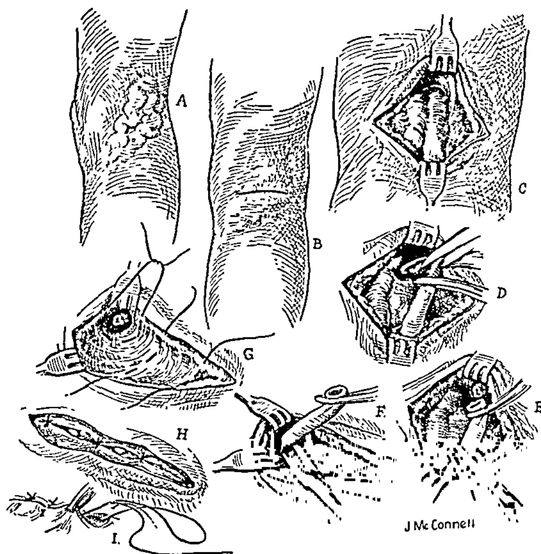


FIG. 433. Ligation of the lesser saphenous vein at its entrance to the popliteal vein in the upper popliteal space. Various steps in the operation are shown.

Ligation of the Lesser Saphenous Vein at Its Entrance into the Popliteal Vein (Fig. 433). When the Trendelenburg test indicates an incompetence of the lesser, or short, saphenous vein, ligation is performed in the upper part of the popliteal space. With the patient standing, the course of the vein is marked on the skin with a colored antiseptic, such as tincture of merthiolate, and the patient is placed on the operating table in the prone position. The posterior lower thigh and the area of the knee are shaved. Usually, the vein enters the popliteal vein a little above an area that can be palpated, because it lies below the fascia at this area. After a transverse infiltration into the skin in the popliteal space, a transverse incision is made, and sharp rake retractors are placed to expose the deep fascia This is separated with a blunt hemostat after it is infiltrated with procaine solution. The vein is exposed and divided between hemostats, as described

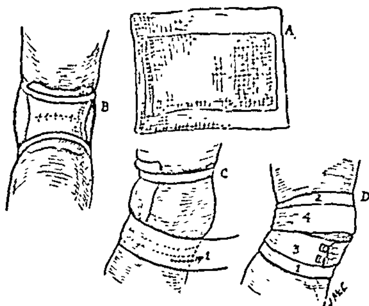


FIG. 434. Dressing following ligation of the lesser saphenous vein.

on page 581. After closing the wound, and with the patient standing, a pressure dressing is applied. Circular elastic adhesive is used; it is placed anteriorly above and below the patella (Fig. 434). The same postoperative instructions as for ligations at the saphenofemoral junction are given (p. 585).

Ligations in the Presence of Ulcers. The ligation of veins is not contraindicated in the presence of varicose ulcers; rather, it is indicated. The ulcer may be treated with compression (see pp. 599–603) at the same time that the vein is ligated.

Ligation of Incompetent Communicating Vessels. When the Trendelenburg test is doubly positive, and when there is evidence of incompetency of communicating veins, it is necessary to ligate the incompetent communicating veins to obtain a successful result. This may be performed wherever the vein is located in the calf or in the thigh.

After preparing the site of operation (see p. 581), local anesthesia is infiltrated in the line of the vein. The skin is incised, and, with sharp retraction, the superficial vein at the junction of the communicating vein is exposed. Usually, it is possible to dissect it free, either above or below the communicating branch. It is divided between hemostats, and the upper and the lower stumps are ligated. When this has been accomplished, the dissected portion of the vein still is attached to the communicating vein, which perforates the deep fascia. This vein may be dissected as far as the deep fascia and ligated at the point at which it perforates this structure. Wound closure with mattress sutures of fine alloy steel wire completes the operation.

Injection Treatment of Varicose Veins

Although the value of preliminary ligations is well recognized as the method of choice in the treatment of varicose veins with incompetence of the valves of the long saphenous vein, many varicosities still remain for which injection treatment is indicated.

Indications for Injection. Chief of these are (1) thin-walled varicose veins

in young women without evident changes in the long saphenous vein in the thigh; (2) painful or disfiguring bursts of small cutaneous varicosities that appear in the calf and the thigh; (3) recurrent varicose veins that have developed following ligation or the old-style excision or stripping operation, (4) varicose veins associated with arthritic pain in the ankle and the knee joints, and (5) the veins that still remain in the calf following primary high saphenous ligation.

The thin-walled veins that indicate early dilatation of smaller venous radicals usually lie directly under the skin, and they respond very well to the action of sclerosing solutions. Cutaneous dilatations, which frequently are painful and disfiguring out of all proportion to their size, likewise can be injected easily with a small needle and the symptoms relieved almost immediately. A 30-gauge needle permits injection of cutaneous veins as small as the needle. The solution may be 50 per cent glucose solution or the foam obtained when one of the soapy sclerosants is shaken in its bottle.

The veins that appear after an operation, especially following stripping or excision operations, are usually thin walled, and they respond very well to injection therapy. Injections, especially of sodium chloride and glucose and other solutions that produce crampy pains, are especially valuable in varicose veins associated with pain in the knee and the ankle. It is the author's opinion that the cramp associated with the injection is one of the valuable parts of this method of therapy. Certain it is that the pain in the region of the joints disappears long before the varices have sclerosed completely. As a matter of fact, this experience of pain relief following the injection of sclerosing solutions that give a cramp has prompted trials at treating painful knees and ankles in patients in whom varicose veins were not a prominent feature. Beneficial results were obtained in many cases.

Contraindications to Injection. The chief contraindication to the injection of varicose veins is a recent thrombosis or phlebitis. Thrombophlebitis is a contraindication when it has occurred in the deep veins, because time must elapse before it can be determined whether the varicose veins are compensatory dilatations or true varicosities. There also is the danger that the reaction induced by the injection may reactivate a latent infection. Therefore, extreme care must be taken in injecting patients who give a history of a previous thrombophlebitis The author has seen only one case of pulmonary embolism in thousands of injections of varicose veins. This occurred following an injection made into the right leg, but it reactivated a previous thrombophlebitis in the left leg. The embolism did not result fatally; however, a cautious attitude has been adopted since in the treatment of patients who have had a recent thrombophlebitis.

Patients with varicosities of the upper thigh and the lower abdomen usually have had a previous partial or complete block of the veins of the pelvis. In such cases, the treatment of varicose veins should be approached with extreme caution because of the fact that the dilated veins frequently are compensatory venous channels.

Varicose veins associated with large uterine fibroids or other pelvic tumors are best treated conservatively by supporting bandages or stockings until the pelvic pathology is corrected.

Equipment and Solutions for the Injection of Varicose Veins. For the proper care of the patient who is to be injected for varicose veins, certain essential equipment is necessary. The treatment table should be high enough for the patient's legs to be seen and examined in the dependent position. The surgeon should sit upon a stool from 12 to 15 in high so that the patient's feet may rest upon his knees. In this way, the veins are distended and located easily for injection. A footstool, upon which the patient may stand, often permits the examiner to palpate the veins to be treated.

SYRINGES. The syringes used are the 2-cc., the 5-cc. and the 10-cc. Luer tip. The author prefers all-glass syringes rather than those with metal tips or finger rings; they are lighter and easier to handle, and the all-glass tip shows the blood as it is aspirated through the needle.

NEEDLES. These should be large enough to carry the solution, but no larger than is necessary for this purpose. For the average injection, the needle with a short bevel, 25-gauge, ¾ in long, is preferred. For the very tiny cutaneous varices a 26-gauge, ½- or 1-in. needle is used.

RUBBER TUBES of 24 in. often are used as tourniquets.

SOLUTIONS The author has found the following solutions to be most useful. Many others have been used with satisfactory results, but these have proven by experience to be preferable.

Glucose 50 per cent is an excellent and safe solution for sclerosing tiny cutaneous veins. In our experience, its escape in the perivenous tissues never has caused a slough. The amount injected may be from 1 cc. to 10 cc.

Sodium chloride 30 per cent and glucose 50 per cent in equal parts give excellent results in sclerosing the larger varicose veins. From 5 to 10 cc. is used, and injection into the vein should be made very carefully because the escape of the fluid into the perivenous tissues may result in a slough. The injection of this solution is associated with a crampy pain in the part and a spasm of the vein. The cramp lasts from 3 to 5 minutes, and it may extend from the foot to the thigh. This solution is especially valuable for the injection of large varices because of the large amount of solution that may be injected, and it is used in all patients who have pains in the region of the ankle and the knee joints associated with varicose veins. From clinical observations, it seems probable that the cramp associated with the injection may be a factor in the relief of the arthritic type of pain in these patients.

Various solutions of salts of fatty acids have been found to be extremely valuable in the injection treatment of varicose veins. The one perhaps that is used most widely is sodium morrhuate, but there are others, such as monoethanolamine morrhuate, monoethanolamine oleate and sodium psylliate (Sylnasol), which produce almost the same sclerosing effect. These solutions are injected in amounts of 1 to 5 cc., depending upon the size of the vein. No more than 5 cc. is injected at one time, although this amount may be divided into smaller injections in several areas. These solutions produce excellent thrombosis, with a moderate reaction at the site of injection. They cause no crampy pain at the time of the injection, although there is some discomfort in the region of the veins almost immediately following. They produce a definite peri-

venous reaction if the injected fluid escapes into the surrounding tissues. This is more in the nature of an acute inflammation or cellulitis of the fatty tissues rather than the sloughing that is seen following the escape of sodium chloride or quinine and urethane. Occasional patients exhibit an allergic reaction following the injection of sodium morrhuate solution. It is for *this reason that the more purified* salts of fatty acids, such as monoethanolamine morrhuate, sometimes are preferable. Their sclerosing effects are as good as those of sodium morrhuate.

Technic of Injection. It is easier to find and inject the veins if the patient's legs are dependent. Therefore, the patient sits upon a table with his foot on the surgeon's knee. If the veins are thin walled and not large, there is no particular value in emptying them before injection. A firm pad of gauze is placed over each injection site and held in place with 2 strips of ½-in. adhesive.

If the vein is large and thick walled, the sclerosing effect is enhanced by emptying it before injection. The needle is introduced into the vein with the leg in the dependent position. The syringe then is held against the leg and the patient is asked to lie down and elevate the extremity. In this way, the vein is emptied, and a rubber-tube tourniquet is placed about the knee or the thigh, depending upon the site of injection. The leg is returned to the horizontal position on the table and the injection is made into the empty vein. The tourniquet holds the solution in the area of the injection for a time and so may increase the amount of sclerosis produced.

It is perhaps unnecessary to say that the injection should not be made until blood is aspirated into the syringe, indicating the presence of the needle tip in the vein. The injection should be made slowly, and the site of the needle tip should be watched carefully to note the appearance of fluid escaping into the tissues. If there is any question as to whether or not all the fluid is entering the vein, the injection should be stopped at once. It *is perhaps a valuable practice to aspirate* once or twice during the injection to make sure that the needle is placed properly within the vein.

After the injection, the patient is asked to lie down for at least 5 minutes. With the leg in the horizontal position, the solution is believed to remain somewhat longer in the segment of vein injected; thus its sclerosing effect probably is enhanced. No bandage other than the adhesive necessary to hold the pad over the injection site is applied. This is removed by the patient the next day.

The injections are made at weekly intervals unless the reaction following the previous treatment is quite marked, in which case the injection is delayed until the reaction has subsided. Often it is possible to inject 2 or 3 sites at the same visit, although it is wise to proceed cautiously and to reinject rather than to overinject.

Effects of Injection Therapy upon Varicose Veins. The purpose of the injection treatment of varicose veins is to set up an inflammatory reaction within the vein lumen. This is accomplished by producing a chemical irritation of the intima of the vein, which in turn leads to a thrombosis due to the destruction of the intimal lining of the vessel. The thrombosis occurs only at the site of the intimal destruction, but there is an intravascular clot that extends in both direc-



FIG. 185. Examples of injection ulcers. Both were treated by excision and primary suture in ambulatory patients.

tions from this primary thrombus. As time goes on, the thrombus and the clots become organized, the result being a closure of the venous radical. If there is a hydrostatic pressure above the area of thrombosis, the thrombus may be canalized, and there may be a reappearance of the varicosity at some later date.

Associated with the thrombosis is a more or less perivenous reaction, characterized by redness, swelling and tenderness along the course of the vein and in the perivenous areolar tissue. Often this reaction extends throughout the course of the vein, and it is sufficient to cause the patient considerable discomfort. By applying a firm elastic adhesive bandage, not only are the patient's symptoms relieved almost completely and immediately, but there is a rapid subsidence of the perivenous inflammation.

In some cases, the perivenous inflammation subsides with the appearance of a purplish discoloration along the course of the vein. If left alone, this area often ulcerates, with the escape of a good bit of partially liquefied clotted blood. This relieves the discomfort, and healing takes place. The process may be shortened and the possibility of ulceration avoided by aspirating this partially clotted blood from the area of the vein involved. Inserting a needle of fair size into the discolored area of the vein, a considerable amount of the material often may be drawn into the syringe. At other times, the blood is so thick that it will not pass through the small bore of the needle; in such cases, the needle is withdrawn, and gentle pressure is made along the course of the vein. The dark semiclotted blood usually will pass through the hole made by the needle, and, if a little time is spent in expressing this material, the discomfort and the pain along the vein disappears. A pressure dressing with elastic adhesive usually is maintained until all symptoms are gone.

The most disturbing complication following the injection treatment of varicose veins is the so-called injection ulcer. Usually, this is due to a faulty technic, especially following injections of quinine and urethane or sodium chloride solutions, in which some of the fluid is permitted to escape into the soft tissues round the vein. The result is a stinging pain in the area, even at the time of the injection, and, as time goes on, there is a definite cellulitis with a secondary necrosis of the skin over the area and the forma-

tion of a deep ulcer with a necrotic base (Fig. 435). The ulcers usually are very painful, and, because the injected solution has sclerosed all vessels in the vicinity, the healing tendency is extremely slow. We have found the most rapid method of healing in such cases to be complete excision of the ulcer area. This may be performed under local anesthesia, the ulcer and the surrounding adipose tissue being excised and the wound closed with interrupted sutures. If excision is not permitted or is not advised, the ulcer can be expected to heal eventually, but it may take several weeks or longer.

Varicose Veins in Pregnancy

Pressure of the enlarging uterus on the pelvic veins, increase in intra-abdominal tension and increase of circulation in the pelvis, all probably are factors in the well-known association of pregnancy with varicose veins. In many cases the pain and the discomfort of the enlarged veins produce the outstanding disability of the latter months of pregnancy. Attempts at relief by the use of elastic stockings and bandages rarely are more than partially successful, and in severe cases the patient may hardly be able to be on her feet at all.

Over the years a general attitude against the treatment of varicose veins during pregnancy has developed. This has meant that many women have endured unnecessarily the discomfort and the disability of varices with each pregnancy Some physicians think it is useless to treat varicose veins before the child-bearing period is over because of the possibility of the recurrence of varices with each pregnancy.

Our experience has proven the truth of Stalker's statement[16] that "varicose veins should be treated as though the pregnancy were not present." Active treatment, whether by ligation, stripping or injection, is safe, and it affords rapid and almost complete relief of symptoms. Veins are treated best in the earlier months of pregnancy, but they can be treated safely even during the seventh or the eighth month if the symptoms warrant it. It should be understood that treatment of varices during pregnancy is not for cosmetic purposes. The veins decrease in size and in extent very remarkably after delivery, so that active therapy in the puerperium should be withheld for about 3 months to permit a more accurate evaluation. (Fig 436)

STASIS ULCERS OF THE LEG

Ulcerations of the lower leg that fail to heal with the usual therapeutic measures often are termed varicose ulcers. This terminology implies that venous stasis associated with varicose veins is the basic alteration. This assumption must be modified by the facts All ulcers of the legs cannot be classified in one group, and an understanding of the underlying *pathology* is necessary for a logical diagnosis and plan of treatment.

Types of Leg Ulcers

Varicose Ulcers. In this type of ulcer the patient's history is quite typical. There have been large varicose veins in the leg for some time, with chronic edema of the ankle. Gradually, replacement fibrosis and pigmentation of the skin appeared, so that the lower leg, especially on the inner side, is hard and discolored and has lost most of the subcutaneous areolar tissue. Then some minor trauma produces a break in the skin; secondary infection follows, and the tissues, having



FIG. 436. (*Left*) Large varicosities of both legs with marked vulvar varicosities in a patient 7 months pregnant. (*Right*) Follow-up 8 months following delivery, showing almost complete disappearance of the veins; the vulvar veins became normal. No treatment was given this patient.



FIG 437. Leg ulcers. (*Left*) Postphlebitic ulcer. Note marked fibrosis and pigmentation of area round the ulcer. (*Right*) Varicose ulcer in usual location.



FIG. 438. Thrombophlebitic edema with area of painful cellulitis above the ankle.

a poor resistance to infection, permit an extension of the infective process and the gradual formation of an ulcer. This is indolent, slightly painful, and, in spite of various ointments and powders, continues to enlarge rather than to close. (Fig. 437)

Postphlebitic Ulcers. There is a history of previous phlebitis, and the leg often is fat without marked varicosities. Chronic edema is present in the lower part of the leg. Without any apparent cause, a painful reddened area of low grade cellulitis develops above the malleolus (Fig. 438). The pain is characterized by a burning, which often is worse at night. As time goes on, the inflammation may subside, leaving an area of fibrosis and induration (Fig. 439). Recurrence of the inflammatory plaques is seen with each episode of prolonged edema. Ulceration may occur as a result of blistering at the area of localized cellulitis (Fig. 440) or following minor abrasions or contusions. The surrounding tissues become indurated, and the ulcer may assume a punched-out appearance. In many of these patients there is no evidence at all of varicose veins, in others, varicose veins are present that at first may have been compensatory dilatations as a result of a deep venous block. As recanalization of the thromboses in the deep veins takes place, the enlarged superficial veins remain as varicosities and contribute to the venous stasis.

Between these two commonly seen ulcers are many variations. In the first, it is more or less evident that the ulceration is a result of the degenerative tissue changes due to venous stasis, upon which is superimposed a traumatic injury with infection. In the second, there is an area of local venous stasis or thrombophlebitis or of some other disturbance of the arteriovenous circulation, with a resulting area of fat inflammation and necrosis followed by ulceration. It is quite possible that, in many of these cases, there is a local increased venous pressure due to an incompetency of the valves of the communicating veins at that point.

The appearance of the ulcer varies according to its duration. In more recent ulcers, there is a small area of granulation tissue; the edges are indurated and cyanotic. There is a constant seropurulent discharge. As time passes, the ulcer increases in extent, its edges are sharp and steep, and its base is dense scar tissue. The surrounding area, at first indurated but



Fig. 439 (*Left*) Typical plaquelike area of pigmentation and fibrosis left after the acute phase of the thrombophlebitic process had subsided. (*Right*) Late stage of thrombophlebitic edema in which there is practically complete loss of subcutaneous fatty tissue, with resulting fibrosis and constriction of the legs above the ankle.

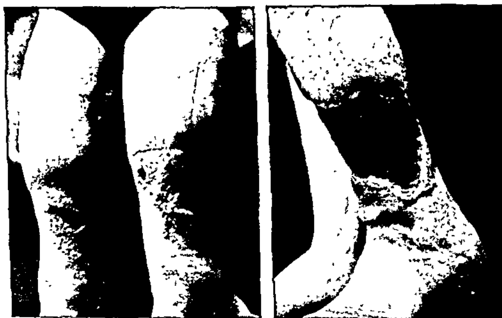


Fig. 440. (*Left*) Relatively early stage of the ulceration in a thrombophlebitic process. (*Right*) Late stage of ulceration following thrombophlebitic edema. Note the punched-out edges of the ulcer, with marked induration and fibrosis round its edge.



FIG. 441. Syphilitic ulcers of the leg. Note that they appear as multiple lesions in the middle, or upper, part of the leg rather than at the ankle, where most varicose and thrombophlebitic ulcerations occur.

pitting on continued pressure, later becomes stony hard, with a dense fibrosis fixing the skin to the underlying fascia. The replacement of subcutaneous fat by scar tissue may extend completely round the leg, separating the foot and the ankle from the upper leg by a contracting band of scar tissue.

Ulcers of the varicose type almost always appear in the lower leg, either above or below the malleolus.

Diagnosis. Usually, there is little difficulty in differentiating the so-called varicose ulcers from others that appear on the leg. The most common lesion to be distinguished from varicose ulcer is that associated with peripheral arterial disease, in which there is a history of burning pain and intermittent claudication after mild exertion. As a rule, the skin is pale and waxy, and there is loss of pulsation in the peripheral arteries. Although these ulcers occur usually on the toes, occasionally they are seen on the lower leg as gangrenous areas that eventually slough out and leave chronic ulcers.

Syphilitic ulcers also appear on the leg; these are seen usually in males of middle life and beyond, and they are due to the breaking down of gummas of the skin and the subcutaneous tissues. There usually is a history of an area of local redness and slight tenderness similar to a low grade cellulitis, which eventually ruptures on the surface or is incised. These areas may be multiple (Fig. 441). If they rupture spontaneously, they form deep punched-out ulcerations, the base being a yellowish-gray color with slight secretion. The ulcers usually are painless. In the author's experience, most of these ulcers have appeared in the upper part of the leg. A positive Wassermann usually fixes the diagnosis, and antiluetic treatment produces rapid improvement.

Ulcers due to tuberculosis also appear on the leg. The process, which is termed erythema induratum or Bazin's disease, arises from true tuberculomas of the skin. These usually are painless nodules that eventually break down, leaving small deep punched-out ulcers with undermined edges and a grayish base. These lesions usually are bilateral and appear in the upper calf, most often in young girls. They are treated best by excision.

Pathogenesis. Although in many cases of varicose ulcer the sequence of events appears to be venous stasis, edema, replacement fibrosis, trauma, secondary infection and ulceration, other cases of leg ulcers can hardly be explained on this basis. These usually are seen in individuals with considerable fatty tissue on the leg. There may or may not be a history of previous

phlebitis, but practically always there has been some swelling in the leg above the ankle followed by the development of an area of firm, painful red induration. On palpation, this area feels hot as compared with the other portions of the leg. These symptoms suggest the presence of an increased arterial flow similar to that of an inflammation, and Zimmerman and Faller[16] suggest that they result from a sequence of changes beginning with a phlebitis and then passing through the stages of periphlebitis and cutaneous induration to the eventual development of eczema or ulcer.

In many patients, especially those with extremely fat legs, the chronic edema is associated with a recurring streptococcic infection; the area of inflammation and induration is not localized but may involve the whole lower leg, and even part of the thigh. The process usually is preceded by an increase of swelling in the leg, and there follows an erysipelaslike redness with swelling, tenderness and a marked systemic reaction with fever, often to 102° and 103°, chills and leukocytosis. The process usually is self-limiting if the edema can be relieved by elevation of the part. In 3 or 4 days, with the use of hot moist applications locally, the entire inflammatory picture disappears. The antibiotic group of drugs has been used, but the impression is that the course is not altered much by their use if elevation succeeds in relieving the edema.

Treatment of Stasis Ulcers

The aim in the treatment of stasis ulcers is to prevent edema This may be accomplished in various ways If the patient can be put to bed with the leg elevated, the edema will subside and the ulcers will heal. To ligate the varicose veins that produce edema by venous stasis will hasten greatly the healing of ulcers, and treatment of varicose veins is not contraindicated in the presence of ulcers. Various types of compression and supporting bandages may be employed in ambulatory patients, and these also may be applied after injecting varicose veins. They prevent venous stasis by obliterating the superficial veins by pressure.

Unna Paste Boot (Fig. 442). In our experience, this has proven to be the most serviceable supporting dressing. It provides a constant compression and protection, permitting rapid subsidence of the edema. The preparation of Unna's paste is given on page 17. The gelatin mixture is warmed in the double boiler until is liquefies enough to be applied with a brush. The entire leg and dorsum of the foot to the toes are painted, and, usually, an extra pad of gauze impregnated with gelatin is placed over the ulcer. A gauze bandage then is applied to the leg over the gelatin. This is more satisfactory if it is started along the side of the foot so that the lowermost turn covers the lowermost portion of the foot. It is carried round the foot and the ankle in figure-of-eight turns until the entire foot and ankle are covered with 1 or 2 layers of gauze. Then it is carried round the leg in circular turns so long as the bandage lies flat. When the conical portion of the leg does not permit circular turns, the gauze is carried upward in spiral turns to the uppermost part of the paste application. There it is reversed loosely and brought down in spiral turns to meet the completed portion of the bandage. Then follow a series of spirals of the leg, reversing at the top until the entire leg is covered with 2



Fig. 442 Unna paste boot. (*Top*) The leg is painted with gelatin paste from the toes to the knee. The bandage is started along the lateral side of the foot: 2-in. bandage is used for the foot-and-ankle portion of the boot. (*Center*) After covering the foot and the ankle, the bandage is continued in a circular manner until it must ascend in a spiral turn in order to lie flat on the part. Three-inch bandage now is substituted for the 2-in. bandage to cover the upper part of the leg (*Bottom*) Reverse turns are made only at the upper part of the dressing.



Fig. 412 (*Top*) After the layer of gelatin and bandage has been applied, the entire bandage is painted again with the gelatin mixture. (*Bottom*) The bandage is completed with one longitudinal ½-in. strip of adhesive on each side, held in place with circular turns

layers of gauze. The bandage is completed with 1 or 2 circular turns at the top. No reverse turns are made on any part of the leg, except at the top of the bandage, and each layer must be pulled snug and made to lie absolutely flat upon the part. Care in this particular will prevent pressure due to tight ridges in the bandages. As a rule, 2-in. gauze bandage is most satisfactory in covering the foot and the ankle and small legs. In large legs, it is better to use a 3-in gauze bandage for the upper portion of the boot.

After the first layer of paste and gauze has been applied, the leg is painted again with the liquid gelatin, the meshes of the gauze being impregnated generously. A second layer of gauze is applied over the paste exactly as was the first. When there is much discharge, a piece of waxed paper may be incorporated over the ulcer between the first and the second layers of the boot. This prevents subsequent soiling of the clothes. In many cases in which the ulcer is deep, further elastic pressure may be obtained by incorpo-

rating a thin layer of sponge rubber over the ulcer between the first and the second layers of bandage. After the bandage is completed, ½-in. adhesive is applied. Longitudinal strips on each side, from the top of the bandage down under the foot and over the dorsum, hold the layers of gauze together, and the whole is anchored by circular turns of adhesive applied about 2 in. apart from the foot to the knee. In performing these circular turns, the middle of a strip of adhesive is applied to the back of the leg, then each end is brought forward round the leg. At the conical part of the leg, the ends must be brought slightly upward toward the knee if the adhesive strip is to lie flat on the part.

The frequency of changing the gelatin boot varies with the patient, the amount of edema of the leg and the amount of secretion from the ulcer. If the boot is applied when there is considerable edema, it should be changed in a week, or even sooner, because, as the edema goes down under the boot, a new boot giving more compression should be applied. If there is no edema when the boot is put on, and there is no marked secretion from the ulcer, the boot may be allowed to remain in place for 3 to 4 weeks to advantage. One patient who failed to keep an appointment wore her boot for 3 months, when it was removed, the ulcer, which had been present for some years, was healed entirely As a rule, because the secretion from the ulcer sometimes produces a maceration of the surrounding tissues, boots should be changed every 2 or 3 weeks. If secretion has produced maceration and superficial ulceration of the skin round the ulcer, the area should be protected with zinc oxide ointment before a new boot is applied, and the boot should be changed as often as once a week until the secretion decreases.

The support afforded by a gelatin boot should be continued for at least 4 to 6 weeks after the ulcer is healed To remove this support too soon often results in a recurrence of the ulcer.

Practical Points in Applying Unna Paste Boots. Before applying Unna's paste to the leg, it should be tested for temperature; burns may occur easily if the hot paste is applied to a chronically edematous leg.

Wide mesh gauze bandage makes a better boot than either the narrower mesh or muslin.

The boot can be applied more easily if a heel rest is available. This permits easier bandaging about the heel and the lower portion of the leg. If a leg rest is used, the heel is placed on one corner of it. The author has had an extra heel rest attached to a leg rest, which has proven to be extremely serviceable (Fig 14). If the bandage is placed well below the malleolus, there usually is no necessity to include the heel in the gelatin boot. If there is any question of swelling below the edge of the boot, the heel should be included.

In applying bandage over the gelatin, each layer must lie flat against the part and be pulled so that it fits snugly; a loose bandage gives practically no support, and, therefore, is almost worthless.

The bandage can be pulled very tight on an edematous part because the edema will disappear under the pressure; thus, constriction need not be feared. However, in cases of ulcers without edema, especially those associated with arteriosclerosis, the bandage should not be applied too tightly because of possible constriction.

The mistake often is made of applying the boot only half way down the foot; this results in an edematous swelling of the dorsum of the foot between the end of the bandage and the toes, which can be avoided easily by carrying the bandage to the base of the toes. In the same way, a bandage that does not reach to the knee often is complicated by an edema above it. The boot should reach to the tibial tubercle anteriorly, and it should include the entire calf of the leg posteriorly, although it should not be high enough to cut the tissues of the knee when the leg is bent.

In hot summer weather it may be advisable to reduce the amount of water by about 25 to 50 cc. in the Unna paste mixture. There is a tendency at this time of year for the paste to run, especially if there is much secretion at the ulcer site.

The patient should be warned against cutting the boot at either the top or the bottom. If a boot is too tight, it must be removed entirely and a new one made. To cut the boot usually causes an edema to the level of the cut and, therefore, more pressure and pain.

Prepared Gelatin Bandages. There are on the market several types of bandages which are impregnated with gelatin mixtures and sold in airtight cans. In our experience, the boots made with them have not been as satisfactory as the Unna paste boot, because they become too hard and tend to cut if they are applied snugly enough to provide compression.

Linton Dressing for Ambulatory Treatment of Stasis Ulcers. Linton has described a somewhat different dressing to be used instead of a gelatin boot to compress the superficial veins of the lower leg in cases of stasis ulcer. He recognizes that it is absolutely essential that any compression dressing "be applied so that it is fixed to the skin in order that it will not move about. If it moves the ulceration will become more painful and will increase in size." To fix the bandage to the skin, an alcoholic solution of resin is painted on the entire leg, except for the ulcer. The ulcer is covered with unmedicated petroleum jelly and gauze, and the lower leg is covered toes to knee with 5 or 6 layers of plain gauze bandage (1 4-in. roll). Cellucotton then is applied in a thick layer over the ulcer and along any large venous trunks, and a second layer of gauze bandage is applied. Finally, the whole bandage, toes to knee, including the heel, is covered with 1 4-in. roll of elastic adhesive bandage applied snugly. This bandage must be changed as swelling goes down and secretion collects, usually in 1 week for the first bandage and in 10 days or 2 weeks for later applications.

Other Types of Supportive Bandages and Stockings. In the treatment of leg ulcers, elastic bandages do not give the compression that can be obtained from a gelatin boot. Nevertheless, there may be instances in which gelatin is not available or other reasons why a boot cannot be applied. In such cases, elastic bandages or elastic adhesive bandages may be substituted. Several types are available; the 3-in. width is probably the most serviceable.

After the ulcer has healed, elastic bandages or stockings often may be substituted for the gelatin boot. This provides continued support for a time and permits the patient to bathe. The light-weight Lastex type of stocking is recommended; it is not nearly as hot or unsightly as the heavier weave elastic stockings, and it gives equal support.

Local Applications to the Ulcer. If it is understood from the beginning that the basic problems in stasis ulcer are venous stasis and associated edema, and that treatment of these two disturbances is essential to the healing of the ulcer, then it matters little what local applications are made to the leg and/or the ulcer.

In the belief that infection is a prominent factor in leg ulcer, various types of local anti-infectious applications have been made. Robinson[11] has applied powdered antibiotics to the ulcers. He thought that chloramphenicol, bacitracin and bacitracin-polymyxin B sulfate gave the best results. The antibiotic powders applied to the ulcer formed a crust that was not removed. Healing took place under the crust. Rutter[13] has used various antibiotics, and he recommends especially a polymyxin ointment for resistant infections with pyocyaneus, to be suspected in sluggish and unresponsive ulcers.

Spier and Cliffton[15] recommend for necrotic ulcers local débridement with plasminogen (a fibrinolytic enzyme) to which has been added streptokinase-streptodornase (Varidase) solution. After the ulcer is cleaned up, hyaluronidase and bacitracin or Terramycin are applied to control infection and cellulitis and to give rapid relief of pain. As soon as redness and edema have subsided, hyaluronidase is used alone in a water-soluble methylcellulose base (methocel).

To cleanse the leg with pHisoHex is common practice. This gives excellent temporary control of skin bacteria, and it is useful when boots or bandages are applied to the leg for weeks at a time.

The number of substances recommended for application to the ulcer site is proof that the ideal h yet been found. Gentian violet, cent solution,[12] is used for its b ostatic effect. Powered gelatin s (Gelfoam)[8] was believed to pr healing when applied under an bandage. Red blood cell[4] past advocated for the same purpose. probable that the supporting ba is the important factor in the s of any of these local treatments. out relief of venous stasis no them succeeds.

"IRRITABLE" ULCER

In many of the ulcers in fa that are preceded by an area of red induration, pain is a very dis ing symptom. It is out of propo to the size of the ulcer, and it persist even after the ulcer has he Whether these ulcers are the resu a phlebitis or a periphlebitic infec or of an abnormal arteriovenous has not been established defini The fact remains, however, that edema may be taken care of easily compression with a gelatin b often there also is some relief of pain, but in many cases the pain p sists in spite of the absence of ede Characteristically, the pain is wo at night, and it may be of such seve as to necessitate the use of morphi

In many such patients, pain may relieved completely by undercutt the ulcer or the painful area if t ulcer is healed. The area about a under the ulcer is injected with 1 p cent procaine solution without e nephrine. A pointed knife then is i troduced from 4 points about the cer, and the knife is rotated as it we on an axis at the skin margin, so th with 4 sweeps of the knife point t ulcer is lifted from its underlying be (Fig. 443). There often is considerab

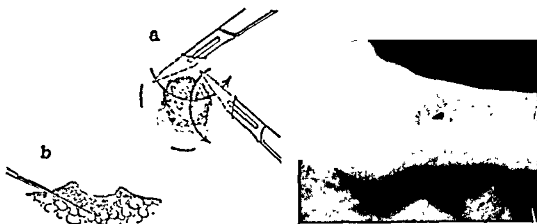


Fig. 443. (*Left*) Method of undercutting an ulcer. The area about the irritable ulcer is anesthetized with procaine 1 per cent, and a pointed scalpel is introduced into the tissues at the edge of the ulcer and carried in an arc as illustrated. (a) Visualized from above (b) Visualized from the side. This elevates the base of the ulcer completely from the underlying tissues. (*Right*) Shows typical painful ulcer which was treated by this method.

bleeding from the holes made by the knife, but this is controlled easily by a pressure bandage. Usually, the patient is provided with 6 tablets of morphine, gr. 1/8, for use during the first night. The pain is relieved almost at once, and the ulcer heals much more rapidly. It never has been absolutely clear what the undercutting accomplishes; perhaps an incompetent communicating or perforating branch is divided by this procedure. However, from a practical point of view, the author is convinced of the value of this procedure in ulcers in which pain is a marked symptom. Occasionally, the simple distention of the tissues beneath and round the ulcer with procaine and saline will give prolonged relief of pain.

GELATIN BOOTS FOR OTHER LEG ULCERS

The compression and support obtained by a gelatin boot is of value in treating not only varicose ulcers but also other types of leg ulcers. It has been used for syphilitic ulcers while antiluetic therapy was being given, for various traumatic ulcerations and for those associated with chronic osteomyelitis. The compression prevents hypertrophic granulation tissue, protects the growing epithelium and, therefore, hastens healing.

STASIS DERMATITIS

Many patients with edema of the lower leg develop a scaling which often develops into a weeping, crusting dermatitis associated with marked itching (Fig. 444). This group of symptoms often is called a stasis dermatitis, although varicose veins may not be a prominent feature when the patient is examined. This change seems to be the result of an edema, and whatever measures are used to relieve the edema relieve also the stasis dermatitis.

In cases in which varicose veins are present, they should be treated, but the essential therapy is some form of dressing that supports the lower leg. A gelatin boot probably is the most



FIG. 441. Stasis dermatitis of the leg. The leg often appears bright red, and there is a weeping edematoid dermatitis.

effective form of support, but in many cases, because of the marked itching and the secretion, boots cannot be used as a primary dressing. In such cases, the application of zinc oxide ointment containing 1 or 2 per cent Ichthyol covered by gauze and elastic bandage is often of value. This same dressing may be applied under a gelatin boot.

Stasis dermatitis usually clears up rather slowly, even with adequate supportive dressings, and these should be maintained for from 4 to 6 weeks after all the scaling has cleared up to permit the skin to return to its normal texture.

AMBULATORY TREATMENT OF THROMBOPHLEBITIS OF THE SUPERFICIAL VEINS

Thrombophlebitis of superficial veins may occur as the result of trauma, or it may develop spontaneously as the result of a latent infection. The portion of the vein involved is a firm, hard, painful cord, often surrounded by a considerable area of tender edematous fat. The skin overlying the vein also may be tender and red. In some patients, there is no systemic reaction, but in others there is a temperature elevation of considerable degree. Most patients are treated by bed rest, elevation and the use of hot packs, and the process subsides gradually in from 2 to 3 weeks.

A much more satisfactory and immediate therapy is available. If a firm elastic adhesive bandage or gelatin boot is applied to the leg, the entire painful process will subside within 24 to 48 hours. The elastic adhesive is applied snugly, and, as a rule, it is begun at the foot and carried up the leg in a spiral to the groin, 2 3-in bandages being used. It is wise to insert a 4 x 8 gauze compress at the back of the knee under the bandage, otherwise pinching of the skin in this area may cause discomfort.

By this method of therapy, the patient's fever subsides within 24 hours, and the pain and the discomfort associated with thrombophlebitis are relieved almost immediately. The patient may be ambulatory throughout the entire period of treatment; from wide experience in treating thrombophlebitis of superficial veins in this manner, the author never has seen a case in which there was even a suggestion of embolism.

The bandage is worn for from 2 to 3 weeks and then removed, and, if the area still is tender on palpation, a new one is applied. In a few cases in which the patient's skin does not tolerate the elastic adhesive bandage, a gelatin boot may be substituted.

A second method of treatment is by ligation and division of the vein above

the area of phlebitis. This is performed best at the saphenofemoral junction, but ligation immediately above the area of thrombosis produces equally good results so far as relief of pain and prevention of embolism are concerned. Probably the best treatment is a combination of the 2 methods, that is, ligation followed by the application of a snug elastic or elastic adhesive bandage. The patient must be up and about throughout his period of treatment; the worst thing he can do is to stay in bed with the foot elevated. This slows the blood flow and favors thrombus propagation and embolism.

With the almost complete relief of symptoms obtained by these methods of treatment, other methods, such as lumbar sympathetic block, have not been found necessary.

Phlebitis and thrombosis of the deep veins of the leg in the acute stage is a disease entity not encountered in ambulatory patients, and the treatment must be carried out in the hospital.

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FIG. 411. Stasis dermatitis of the leg The leg often appears bright red. and there is a weeping edematoid dermatitis.

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Foot and Ankle

INFECTIONS

Infections of the foot correspond roughly to those of the hand, except that tenosynovitis is not a frequent lesion in the lower extremity.

Cellulitis and Lymphangitis

Etiology and Symptoms. A common infection in the foot is cellulitis with an associated lymphangitis, which arises from an infection of the toes or a dermatophytosis between them. This is either primarily or secondarily streptococcal in origin, and the usual history is of some small, often insignificant, abrasion or crack in the skin followed by the development of edema and cellulitis of the dorsum of the foot with typical red streaks of lymphangitis up the leg. The subinguinal nodes overlying the saphenous opening are the ones involved most frequently, and these become enlarged and painful, often without any apparent intervening lymphangitis The same type of infection may arise from an infected blister over the heel or over the metatarsophalangeal joint of the great toe.

Treatment. The treatment of streptococcal infection of the foot consists of elevation, hot wet dressings over the foot, the leg and the involved lymph nodes, and administration of antibiotics, usually penicillin. This therapy necessitates bed treatment, but usually it can be carried out safely at home and results in a rapid subsidence of the infection in 2 or 3 days. However, the possibility of a later development of a suppurative adenitis in the lymph nodes involved should be remembered; this may demand incision.

Infected Callus

A second type of infection that is seen occasionally in the foot is a local one about a callus on the plantar surface. This lesion is similar to the collar-button abscess seen in the hand (p. 199), and it is treated in the same manner.

Treatment. The overlying thickened skin is incised, and the subcutaneous abscess is drained by spreading the small opening through the true skin with a hemostat. A small drain and hot wet dressings result usually in a rapid subsidence of the infection. Antibiotics are useful adjuncts. During the course of this treatment, the patient should be off his feet, with the part elevated.

CHRONIC ULCERS OF THE PLANTAR SURFACE OF THE FOOT

Diagnosis. Chronic ulcers in the center of callosities on the plantar surface of the foot occur especially in older individuals and most often in diabetics. These ulcers are characterized by a heaping up of thickened epithelium, in the center of which is a punched-out ulceration (Fig. 445).

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Infected Callus

A second type of infection that is seen occasionally in the foot is a local one about a callus on the plantar surface. This lesion is similar to the collar-button abscess seen in the hand (p. 499), and it is treated in the same manner.

Treatment. The overlying thickened skin is incised, and the subcutaneous abscess is drained by spreading the small opening through the true skin with a hemostat. A small drain and hot wet dressings result usually in a rapid subsidence of the infection. Antibiotics are useful adjuncts. During the course of this treatment, the patient should be off his feet, with the part elevated.

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FIG. 415. Chronic ulcer and callosity of the plantar surface of the foot in a diabetic. Note the punched-out appearance of the ulcer, which extends deeply, even into the bone of the foot. This patient was treated with gelatin boots, and for more than a year and a half was able to get about on the foot. Eventually, infection necessitated amputation.

When they occur over the ball of the foot, they extend sometimes to the heads of the metatarsal bones. In addition, there often are roentgen changes in the bone, and these frequently are misdiagnosed as osteomyelitis. In reality, they are the changes of osteoporosis, although a secondary infection may lead to a true inflammation of the bony tissue.

Treatment. These ulcers are very resistant to all forms of treatment, and often they become infected secondarily. In diabetic patients, they may have serious consequences, even amputation.

The ulcer probably is the result of a reduced blood supply in the area, with a consequent decrease in healing power. Protection of the part with a Unna paste boot permits these patients to get along very nicely. We have had 1 patient who lived 4 years at least without infection with this type of dressing.

TRAUMATIC LESIONS

INCISED WOUNDS

Incised wounds of the feet occur most commonly from stepping with the bare foot on some sharp object, such as glass or a razor blade.

Treatment. The care of such injuries does not differ from that for incised wounds elsewhere in the body (p. 158). As a rule, the preparation of the surrounding area, followed by cleaning of the wound itself, permits primary suture. A pressure bandage is applied, and the patient usually is provided with crutches for a time.

PUNCTURE WOUNDS

Etiology. Puncture wounds probably are more common in the foot than elsewhere in the body. Pointed objects may enter the foot through the shoe, as when one steps on a nail in a board, or needles or other sharp-pointed objects left lying on the floor may enter the foot directly when one walks barefoot about a room. Often the patient does not seek treatment for several hours, or even days.

Treatment. As a rule, it is safer to administer a prophylactic dose of tetanus antitoxin or give a booster dose of toxoid. The treatment of the wound itself depends somewhat upon its condition. In the primary dressing, it is usually unwise to probe the wound, and, in a large majority of cases in which a simple protective dressing is applied, healing occurs without infection. If there is reason to believe that considerable contamination has been introduced with the puncturing object, it is wise to incise the wound under local anesthesia and to perform a radical wound cleansing. Prophylactic use of antibiotics is the rule in such cases.

Foreign Bodies

Many puncture wounds are complicated by the presence of foreign bodies in the feet. Needles and splinters are the most common offenders.

Treatment. A splinter has little tendency to move in the tissues, and, as a rule, it can be traced from the wound of entrance and found easily. It should be removed under local anesthesia with tourniquet hemostasis. The entire wound usually is laid open, unless this involves incision of deep and important structures After thorough cleansing the wound is closed; a pressure dressing is all that is necessary.

When the foreign body is a sharp-pointed instrument, such as a needle, removal should not be attempted until a roentgen localization is performed (Chap. 11, pp. 168-169). The reason for this is that walking on the foot and the motion of the tendons often make the foreign body move a considerable distance from the site of entrance and removal is difficult without accurate localization. The patient should not be allowed to walk on the foot from the time the roentgenogram is made until after operation.

In searching for such foreign bodies, a blood-pressure-cuff tourniquet is essential to control bleeding. With the roentgen films at hand, an incision devised to reach the foreign body through the shortest possible route is made under local anesthesia. As a rule, the needle oxidizes rapidly in the tissues, so that it appears as a black speck in the wound. Once it has been located, it may be grasped with hemostat or forceps and pulled out. There is no necessity for complete exposure of the entire tract of the foreign body. The wound is closed loosely; there is not much danger of infection in such cases. Penicillin intramuscularly is worth while as prophylaxis against infection.

Contusions

Contusions of the foot and the toes are common industrial accidents when the foot is caught under heavy machines, rolling barrels or trucks. Often there is a fracture of the distal phalanx of the great toe and other bones of the toes Therefore, such injuries always should be examined by roentgenography. The swelling usually is quite marked on the dorsum of the toes and on the dorsum of the foot. Frequently there is a subungual hematoma, or the base of the nail may be torn free and lie on top of the eponychium.

Treatment. Following roentgenography, the lesion is cleaned if there are wounds, and any part of the nail base that lies on the eponychium is excised. The wounds then are protected with petrolatum gauze, and the whole foot and ankle are enclosed in a compression dressing of Unna paste (p. 17). Gauze soaked in the warm Unna paste is applied between each toe, then foot and toes are well soaked with gelatin. A bandage is applied, the ends of the toes being covered with one compress dressing soaked in the gelatin mixture. Two or three layers of alternating gelatin and gauze comprise the dressing.

The advantage of this dressing is that it supplies comparative immobilization, as well as pressure, and, with this therapy, the swelling and the pain subsides rapidly and the patient, even in the case of severe contusion and fracture may be able to walk without too much discomfort in 2 or 3 days to a week. The dressing is al-

lowed to remain in place as long as it is in good condition, which often is 3 to 4 weeks. During this time, the patient can be ambulant without much disability with a shoe cut out at the toe.

Blisters

Abrasions are relatively infrequent on the foot, because usually it is very well protected. However, friction and pressure due to ill-fitting shoes often produce blisters. These are especially frequent over the metatarsophalangeal joint of the great toe and over the heel. At first, there is a burning sensation, and, with longer wearing of the shoes, a definite blister appears.

Treatment. The treatment of these lesions is removal of the pressure and the friction causing them. Old shoes should be worn; these are cut over the involved joint or cut down at the heel. The blister area, if it is not too large, may be protected simply by a gauze pad or, occasionally, by the use of a felt circle, such as those sold for the protection of bunions. By protecting the area from further friction, the hyperemia and the blistering often subside spontaneously. If the blister ruptures, a raw, painful area is left and must be protected from further friction. This can be done with gauze cut with a small hole in it. Boric acid ointment may be applied to prevent the adherence of the blister base to the overlying gauze.

The danger from blisters is infection, usually streptococcal, with lymphangitis or cellulitis. Prophylactic use of antibiotics is indicated.

Corns

Description. Corns are a variety of callosity in which there is a central piling up of epithelial cells forming what frequently is called a core. They are the result of pressure and friction, and they are seen most commonly over the lateral and the dorsal surfaces of the fifth toe, though they may occur also over any bony prominence. Corns are described as being either hard or soft; this differentiation is due only to the amount of moisture in the area. Those occurring between the toes become macerated and are called soft corns, whereas those on the dorsum of the foot and the toes have a hard, horny epithelial covering. Soft corns often are associated with dermatophytosis.

Treatment. In the treatment of corns, the most important factor is the removal of the cause. Frequently, the correction of ill-fitting shoes or improper weight-bearing of the feet permits the corn to disappear. However, if corns are to be removed, a scalpel or electrocoagulation may be used. A most conservative method, that of shaving away the hardened epithelium followed by an application of trichloracetic acid, is sometimes effective. Any local therapy without removal of the cause of the pressure is almost sure to be followed by a reappearance of the corn.

Sprains and Ruptures of Ligaments About the Ankle Joint

Etiology and Symptoms. Sprains at the ankle occur most commonly at the outer side. Sudden inversion of the foot causes an injury to the external lateral ligament, manifested by limping and pain, with swelling, ecchymosis and tenderness at the outer side of the ankle. A similar condition may occur at the inner side of the ankle. Sprains usually can be differentiated from fractures by the location of the most acute tenderness. In sprains, this

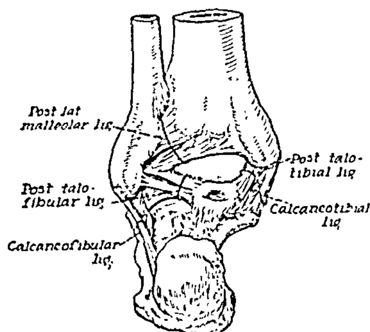


Fig. 446. Semidiagrammatic posterior view of the ligaments at the ankle (after Spalteholz). The outer malleous is bound strongly to the posterior aspect of the astragalus and to the os calcis, and it often is displaced with them after fractures

is the area in front of and below the outer malleolus; in fractures, it is definitely over the bone (Fig. 636).

Very often, the anterior tibiofibular ligament is found to be tender, and there may be tenderness over the dorsum of the foot in front of the ankle. These indicate sprains of the tibiofibular ligament and the ligaments of the dorsum of the foot. Occasionally, the lateral ligament tears away from the malleolus and takes with it a small portion of the tip of the bone This condition is called sprain fracture.

When the signs of sprain at the outer or the inner side of the joint are severe, a very extensive laceration of the ligament involved may be present. Similarly, great tenderness at the tibiofibular ligament indicates possible rupture. These are suspected more strongly when the foot can be inverted or everted forcibly beyond its normal limit and when the astragalus is felt to rotate excessively between the malleoli, indicating that the injury is a reduced dislocation. Normally, the astragalus does not move sidewise.

The test is performed best after the tender areas have been infiltrated with 10 cc. of 1 per cent procaine solution. When excessive sidewise mobility is found or is suspected, it should be verified by making an anteroposterior roentgenogram of *the ankle with the* foot inverted or everted forcibly as the case may require so as to put the ligament affected on tension.

Treatment. Sprains and sprain fractures without abnormal mobility of the astragalus require support of the ankle joint and measures to control swelling A strapping (Figs. 447, 448) provides a firm supportive dressing, this is renewed when it becomes loose. Elevation and application of ice bags for from 24 to 48 hours will control swelling. The patient continues his usual activities so far as possible. Recovery takes place in from 3 to 14 days as a rule. Another method of treatment is to have the patient begin vigorous active use after the strapping is applied. Often, there is striking subsidence of symptoms after a few hours.

Procaine injections may be used in

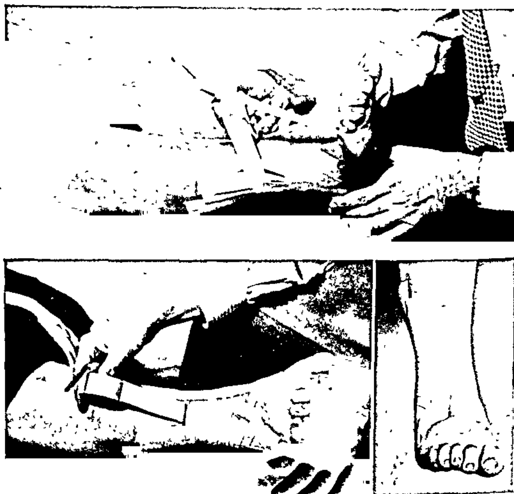


FIG. 447. Ankle strapping (Gibney boot). (*Top*) The heel is supported on the surgeon's knee, and the foot is held in a bandage loop at right angles to the leg by the patient. Alternate longitudinal and transverse strips of 1-in. wide adhesive are applied from a roll. Each strip should lie flat on the part. Except for the dorsum of the foot, the entire area is covered by varying the direction of the adhesive strips. (*Bottom, left*) Rolling of the adhesive edges is prevented by longitudinal binding strips, these are nicked with scissors to permit them to conform to the part (*Bottom, right*) Completed strapping.

treating these injuries, 10 cc. or more of 1 per cent solution being injected at the site of the most acute tenderness. The joint then is moved about to find any other painful areas and is palpated for additional tender spots. Any such areas should be injected also with from 5 to 10 cc. of solution. Immediate relief of pain and the ability to walk freely result. The pain may return after some hours; it may or may not be severe. Additional injections may be given at intervals of 24 hours or more Recovery is expedited by strapping the ankle as described.

When the signs of sprain are associated with abnormal mobility of the astragalus, rupture of the external lateral, the internal lateral or the tibiofibular ligaments must be suspected and verified by roentgenograms. Prolonged immobilization is

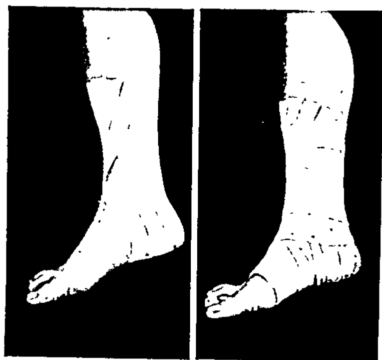


FIG. 118. Simple strapping and elastic adhesive bandage dressing for sprains of the external lateral ligament or sprain fractures of the tip of the outer maleolus. Both injuries are caused by inversion, which the strapping prevents



FIG. 449. Adhesive strapping for sprains of the metatarsophalangeal joint and of the joints of the toes. This strapping also is used frequently for fractures of the phalanges of the toes. It is a most effective dressing and much better than any form of splint. It should be applied with the patient standing on a stool and bearing his weight on the affected foot (*Left*) Cross strappings extending from the dorsum of the foot to the end of the toe are applied. (*Center*) The longitudinal strips are anchored with circular turns of adhesive, applied with the patient extending his toes beyond the stool on which he is standing. A loop of adhesive is placed under the toe. The patient again places the entire foot on the stool and bears his weight on the foot, and the circular turn is completed If these circular turns are put on while the patient's weight is borne on the foot, the strapping will be comfortable. otherwise, the tendency is for the toe to be held in extension and make the patient uncomfortable. (*Right*) The circular turns of the upper portion of the strapping are placed round the foot while it is lifted off the stool With the patient again bearing his weight on the foot, the turns are completed.



FIG. 450 (*Left*). Subungual wart of the great toe. This wart was cured by electrocoagulation under local anesthesia.

FIG. 451 (*Right*). Subungual papilloma. These are enlarged warts, and they are treated in the same manner as warts.

necessary to secure firm healing of the rupture. Two lateral plaster splints and a pressure dressing are applied (Fig. 613), and elevation and ice bags are prescribed. When the swelling subsides, an unpadded cast is applied from the toes to the knee (Fig. 611), the malleoli being compressed firmly together with the flats of the hands and the plaster being molded well. A total of 6 weeks of immobilization is required. The patient begins to bear weight immediately after the cast is hard and the walking iron or heel has been applied. The after-care is similar to that for ankle fractures without displacement. If prolonged immobilization and the walking prescribed are carried out, the prognosis usually is good.

Sprains of the Metatarsophalangeal Joint

Treatment. Stubbing the toes, especially when walking barefoot or in soft slippers, often results in a sprain of the metatarsophalangeal joint, especially that of the great toe. This causes swelling and pain on motion. The pain often may be relieved by the injection of a local anesthetic, usually procaine 1 or 2 per cent. A strapping applied along the dorsum of the foot and the toe provides relative immobilization, and gives comfort and rapid subsidence of the painful symptoms. It is essential that the patient bear his weight on the foot while the strapping is being applied, otherwise the toe often is strapped in the hyperextended position, which gives more discomfort than the original lesion (Fig. 449).

LESIONS OF THE TOENAIL

Subungual Warts

Warts under the toenails are troublesome lesions (Figs. 450, 451). By pressing on the undersurface of the nail, they frequently cause pain and disability. Patients usually attempt to relieve their discomfort by cutting

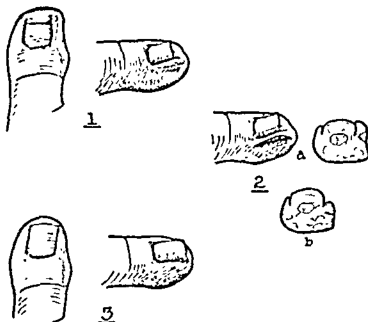


Fig. 452. (1) Drawing of an ingrown toenail to show how cutting the nail too short permits a buried corner to remain and grow upward as a point under the soft tissues. (2) Bartlett operation for ingrown toenail which is especially valuable when there is no infection A wedge of soft tissue is excised along the side of the toe (a), and the wound is sutured primarily (b) This pulls the soft tissues away from the edge of the nail. (3) Proper cutting of the nail, showing the entire nail edge beyond the soft tissues.

away the nail round the wart, but, as the nail grows out, it tends to cut into the wart, causing pain and sometimes infection

Treatment. The warts may be removed either by cauterization with an electrocoagulating needle under local anesthesia or by the injection into the base of the wart of a drop or two of a sclerosing solution, such as quinine and urethane. The nail should be cut back from the area until the wart separates and comes away.

Subungual Hematoma

This occurs in the toes, especially under the great toenail, as under the nails of the fingers (p. 510). Even a small amount of blood between the nail and the nail bed produces excruciating pain.

Treatment. Subungual hematomas are relieved easily either by cutting an opening in the nail or by elevating the eponychium from it, permitting the escape of blood from under the nail base. A pressure dressing of adhesive is all that is necessary.

Ingrown Toenail

Etiology. Ingrown toenail is a painful lesion caused by pressure of tight shoes on the soft tissues at the edge of the nail of the great toe. The secondary, or exciting, cause of the difficulty is the frequent mistake of cutting the nail too short, so that its corner may be overlaid easily by the soft tissues at the edge of the nail. As the nail grows out, the uncut corner is pushed into the soft tissues (Fig. 452), and the pressure of the shoe on the



FIG. 453 (*Left*). Infection along the edge of the nail in a typical ingrown toenail.

FIG. 454 (*Right*). Neglected ingrown toenail with growth of hypertrophic infected granulation tissue along the edge of the nail.

tissues produces marked pain. Frequently, the sharp projecting tip of the nail produces an ulceration in the skin overlying the nail edge, and this causes a chronic infection (Fig. 453). Granulations form over the nail edge, and there is a constant discharge of a small amount of purulent secretion (Fig. 454). In this type of lesion, the discomfort is more or less constant, but it is made much worse by the pressure of shoes.

Treatment. The treatment of ingrown toenail may be divided into the conservative and the operative. In many people, the discomfort may be relieved without anesthesia by excising the side of the nail with the tip of a scalpel, thus removing the factor that causes the pain. The overhanging granulations may be cauterized with a silver nitrate stick, and, if precautions are taken to prevent pressure by wearing shoes that fit properly, the patient's symptoms may be relieved completely and often permanently.

In many cases, it may seem to be wise not to attempt conservative therapy, but, rather, some form of operative treatment. Two methods of operation have been employed, and we have found specific indications for each type. The operation described by Bartlett* has been found to be of particular value in those patients in whom the pain from the ingrown toenail is not associated with an infection along the edge of the nail (Fig. 452). In this operation, using local anesthesia, an ellipse of skin and subcutaneous tissue is excised along the side of the toe. The wound is sutured primarily, and a simple pressure dressing is applied with adhesive. The sutures are permitted to remain in place for 7 days at least, and often the dressing is not changed until this time. The advantage of this operation is the rapid, usually primary, healing and the relatively short period of disability of not more than a day or two.

* Bartlett, Robert W.: A conservative operation for the cure of so-called ingrown t nail, J.A.M.A. 108:1257- ~ 937.

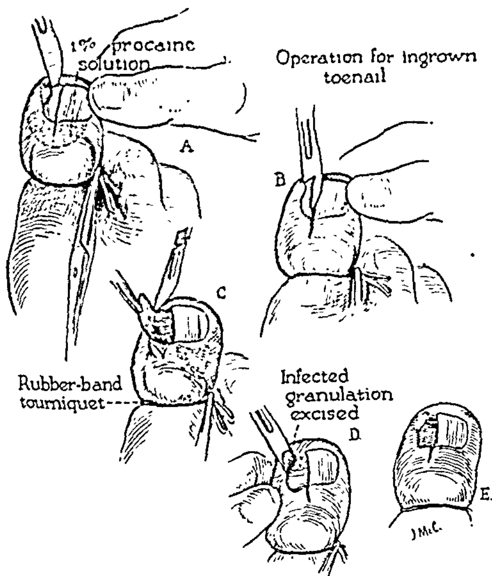


FIG. 155. Operation for ingrown toenail. (A) The eponychium at the base and the sides of the nail is infiltrated with 1 per cent procaine solution. The anesthesia should extend upward to the soft tissues at the tip of the toe. A tourniquet, consisting of a rubber tube or band, is placed round the base of the toe An incision is made through the nail and the eponychium with a knife or scissors. (B) The nail is reflected from the phalanx throughout its entire length, including the matrix. (C) The nail is dissected away, tension being kept upon it with forceps or a hemostat. (D) After the entire nail and matrix have been removed, the infected granulation tissue is excised. (E) Petrolatum gauze or a small piece of Gelfoam is placed over the resulting wound, and a pressure dressing is applied.

Excellent permanent results are obtained by this treatment, which is designed to pull the soft tissues away from the edge of the nail.

For ingrown toenails in which there is a definite infection along the edge of the nail with a heaping up of chronic granulation tissue, a much



FIG. 453 (*Left*). Infection along the edge of the nail in a typical ingrown toenail.

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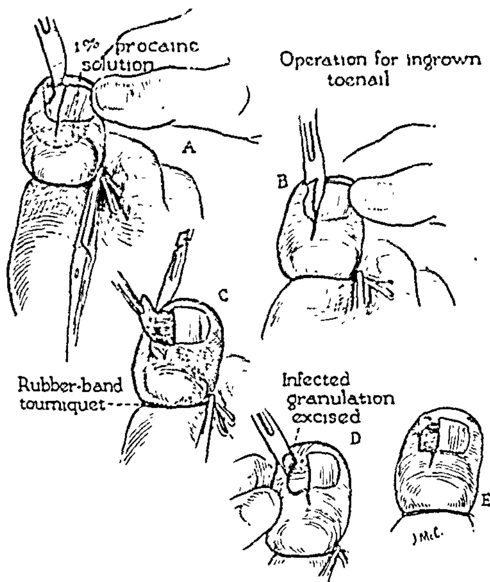


FIG. 155. Operation for ingrown toenail. (A) The eponychium at the base and the sides of the nail is infiltrated with 1 per cent procaine solution. The anesthesia should extend upward to the soft tissues at the tip of the toe. A tourniquet, consisting of a rubber tube or band, is placed round the base of the toe. An incision is made through the nail and the eponychium with a knife or scissors (B) The nail is reflected from the phalanx throughout its entire length, including the matrix. (C) The nail is dissected away, tension being kept upon it with forceps or a hemostat. (D) After the entire nail and matrix have been removed, the infected granulation tissue is excised. (E) Petrolatum gauze or a small piece of Gelfoam is placed over the resulting wound, and a pressure dressing is applied.

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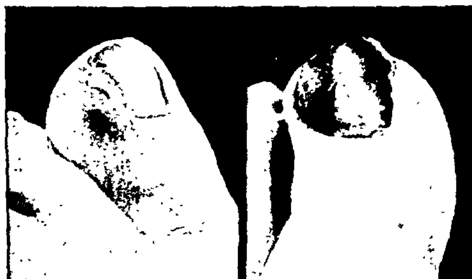


FIG. 453 (*Left*). Infection along the edge of the nail in a typical ingrown toenail.
FIG. 454 (*Right*). Neglected ingrown toenail with growth of hypertrophic infected granulation tissue along the edge of the nail.

tissues produces marked pain. Frequently, the sharp projecting tip of the nail produces an ulceration in the skin overlying the nail edge, and this causes a chronic infection (Fig. 453). Granulations form over the nail edge, and there is a constant discharge of a small amount of purulent secretion (Fig. 454). In this type of lesion, the discomfort is more or less constant, but it is made much worse by the pressure of shoes.

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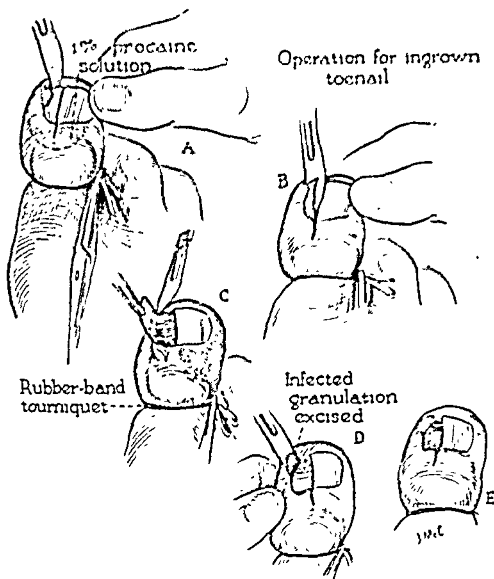


FIG. 155 Operation for ingrown toenail (A) The eponychium at the base and the sides of the nail is infiltrated with 1 per cent procaine solution The anesthesia should extend upward to the soft tissues at the tip of the toe A tourniquet consisting of a rubber tube or band, is placed round the base of the toe An incision is made through the nail and the eponychium with a knife or scissors. (B) The nail is reflected from the phalanx throughout its entire length, including the matrix (C) The nail is dissected away, tension being kept upon it with forceps or a hemostat (D) After the entire nail and matrix have been removed, the infected granulation tissue is excised. (E) Petrolatum gauze or a small piece of Gelfoam is placed over the resulting wound, and a pressure dressing is applied

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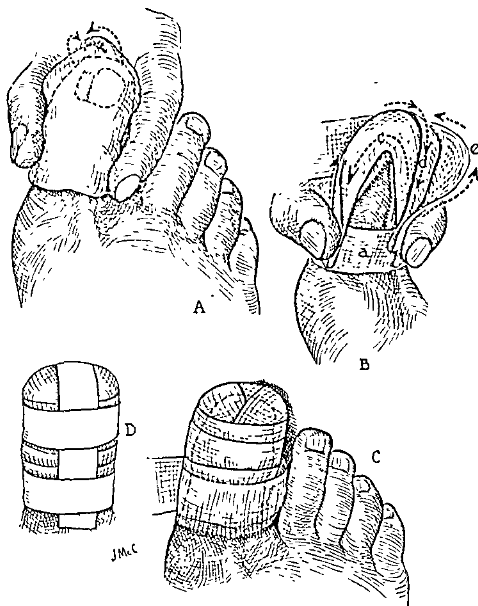


Fig. 456 Dressing of the toe for use following excision of an ingrown toenail. (A) A gauze dressing 2 x 8 in. is cut at the top and folded over the end of the toe. (B) A circular anchor turn of bandage is applied, followed by a recurrent bandage over the toe. (C) The bandage is finished by circular turns (D) Adhesive strips are applied, 1 longitudinally, which extends beyond the bandage front and back, and 2 circular turns, which anchor the bandage and the longitudinal adhesive strip in place.

better operation is excision of the side of the toenail and of the overhanging soft tissues (Figs. 455, 456). The operation is performed under a block anesthesia at the base of the nail and round the edges of the toe. A tourniquet at the base of the toe provides hemostasis. With knife or



scissors, the toenail is divided down to and through the matrix. This includes also an incision in the eponychium, which is turned back with Allis forceps. The scalpel then is inserted under the uplifted cut edge of the nail, and the offending portion of the nail is removed with its matrix. The hypertrophic granulation tissue and the soft tissues that overhang the nail are excised, and the resulting wound is overlaid with a small piece of Gelfoam. A pressure dressing is applied. The gauze is changed in about 3 days; after that, small protective dressings are continued until the wound is healed, which takes place in about 2 to 3 weeks.

In the ambulatory care of patients with ingrown toenail, the toe of an old shoe can be cut out to permit the application of a bandage without pressure on the toe. Obtaining an old shoe is these cases often makes it necessary to delay operation for 24 hours. During this time, hot soaks are suggested to relieve the infection and the local cellulitis that may surround the nail edge.

The patient should be warned after operation that the wearing of tight shoes with pressure on the edge of the nail may cause recurrence of an ingrown nail. Instructions also should be given about permitting the nail to grow so that the edge extends beyond the soft tissues.



FIG. 457 Subungual exostosis of the great toe.

Subungual Exostoses

Exostoses spring occasionally from the dorsal surface of the distal phalanx of the toes, especially of the great toe (Fig. 457). This bony overgrowth pressing upon the nail causes marked

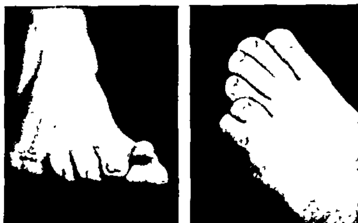


FIG. 458 (*Left*). Hypertrophied toenail. In this patient, the shoe pressed on the hypertrophied nail and caused considerable pain. It was treated conservatively by cutting away the toenail, and the patient was taught to keep it in check by frequent filing.

FIG. 459 (*Right*). Supernumerary fifth toe, which was excised under local anesthesia.

pain, and there usually is some deformity of the nail over the exostosis. A roentgenogram, especially a lateral view, shows the presence of the bony growth.

Treatment. The symptoms can be relieved by removal of the exostosis. This operation necessitates removing the nail and chiseling away the bony growth or removing it with rongeurs. It can be performed under local anesthesia, a tourniquet being used at the base of the toe to control bleeding. After removing the nail and the exostosis, a pressure dressing is applied.

Ringworm of the Toenail

Ringworm often infests the toenail as it does the fingernail (see Chronic Paronychia, p. 488). The appearance is quite typical. There is a moth-eaten, roughened nail with fragile edges. Frequently, an eponychial or paronychial type of infection is associated with it.

Treatment. In some cases, the treatment of the dermatophytosis by local applications and hot permanganate soaks and, occasionally, by roentgenradiation is satisfactory. In many cases, however, it is necessary to remove the nail in order to effect a cure (see p. 488).

Hypertrophied Toenail (Onychogryphosis)

Etiology and Symptoms. Hypertrophy of the toenail occurs most frequently in the nail of the great toe (Fig. 458). As a rule, the cause of the overgrowth is some trauma to the nail bed, with subsequent marked thickening of the nail. Often, an almost hornlike nail develops, especially in older people who have a tendency to neglect themselves. The hypertrophy may cause pain by pressure upon the toe by the shoe, and it is for this reason that many patients seek treatment.

Treatment. If it is recognized that the symptoms may be relieved by relief of pressure, then conservative therapy, consisting of simple excision of the hypertrophied nail, may be tried. Bone-cutting forceps are used to cut off the excessive nail, and the patient is taught to file away the overgrowth as necessary. This will not produce a cure, but it will relieve the symptoms.

Removal of the nail often is a disappointing procedure because of the fact that the deformity recurs sometimes. For this reason, careful excision of the nail matrix must be performed in addition to removing the nail as a further precaution against regrowth.

Some authors advise cauterization of the nail base. The operation can be done under local anesthesia.

SUPERNUMERARY TOES

Supernumerary toes (Fig. 159) are not at all uncommon, and, because of the difficulty they may cause in wearing shoes, it is necessary frequently to remove the extra digit. This can be done best in childhood, because the growing child is able to adjust to the joint deformity that may follow to removal of the extra toe and its articulations.

Treatment. The operation is performed easily under local anesthesia. A roentgenogram aids in deciding which portion of the several toes should be removed. The toe is given a block anesthesia at its base for excision. It is wise to carry the skin incision fairly high along the toe to be removed. This flap of skin is reflected back sufficiently from the toe articulation to ensure sufficient skin and subcutaneous tissues to close over the defect resulting from removal of the extra toe. Skin sutures that pass through the entire underlying soft tissues and to the bone are necessary. Fine steel wire is an excellent suture material. A pressure dressing is applied without a splint. The patient may be ambulatory throughout the period of treatment.

OSTEOCHONDRITIS OF THE HEAD OF THE SECOND METATARSAL BONE (FREIBERG'S INFRACTION, KOHLER'S DISEASE)

Etiology. This is an aseptic necrosis of the head of the second metatarsal and less often of the third, the fourth and the fifth metatarsals. This necrosis occurs usually as a result of trauma; it is a progressive lesion, producing a flattening of the head of the metatarsal bone and joint mice consisting of bits of loose cartilage discharged into the joint (Figs. 160, 461). As the process continues, increasing pain develops in the region of the joint affected.

Treatment. Conservative therapy by means of various types of pads may be tried, but usually it is unsuccessful and resection of the head of the metatarsal bone, or at least a reshaping of the head of the bone, is necessary. Operative therapy usually demands casting and hospitalization.

GANGLIA OF THE FOOT

Mucoid cysts or ganglia appear on the dorsal surface of the distal phalanges of the toes much as they do in the distal phalanges of the fingers (p. 531) Occasionally they cause pain due to pressure, and they can be excised easily under local anesthesia with primary suture of the wound (p. 209).

Ganglia of the foot are not nearly as common as those of the hand and the wrist. However, they do occur, especially on the tendons along the lateral side of the dorsum of the foot (Fig 162). Trauma seems to play a greater etiologic role in their formation than can be demonstrated in those of the wrist and the hand. They are treated by excision under local anesthesia (p. 209).

FAULTY WEIGHT-BEARING OF THE FEET

FLATFEET

Improper weight-bearing, due to flattening or weakening of the arches of the foot or to a congenital shortening of one leg, may be the cause of





FIG 460 (*Left*). Relatively early stage of Freiberg's infraction, showing the osteochondritis and beginning flattening of the head of the second metatarsal bone.

FIG. 461 (*Right*). Advanced stage of Freiberg's infraction, showing marked flattening of the head of the second metatarsal, with deformity of the metatarsophalangeal joint. This patient was cured by excising the deformities of the joint surface and rounding off the head of the second metatarsal with a file. The operation necessitated hospitalization, although it was performed under local anesthesia.

many symptoms, not only in the feet, but also in the legs, the knees and even in the back.

In the common type of flatfoot, the heel pronates and the forefoot supinates, so that the arch flattens out. This overstretches the muscles on the inner side of the leg and allows the gastrocnemius, which now lies toward the outer side, to increase the deformity. The excessive tension on the inner muscles and the tension placed on the inner side of the knee often manifest themselves by pain and great tenderness at the medial side of the knee.

Symptoms. The symptoms are an aching pain after the patient has been on his feet for a while, and often a painful swelling and edema of the foot and the ankle. There may be also a local tenderness on deep palpation. In addition to these symptoms in the foot, an aching in the calf of the leg and pains in the knee and even in the back may result from long-continued strain of the ligaments due to improper weight-bearing in the foot.

Examination. The examination should be performed with the patient barefoot. The feet should be observed both before and after weight is borne on them. On standing, there is a characteristic lowering, even entire loss, of the longitudinal arch on the medial side of the foot. The forefoot may deviate laterally, the heel when viewed from behind may show the os calcis angulated, and the foot may appear



Fig. 462 (*Left*). Ganglion of the foot. This was excised under local anesthesia.
Fig. 463 (*Right*). Plantar wart of the foot.

to be everted on the ankle (Fig. 113). The Achilles tendon appears to lie laterally, so that its pull and ordinary weight-bearing increase the deformity at the ankle. The soles of the feet then are inspected when the patient sits down. Some patients show plantar skin of even thickness, but a considerable number show a dense thickening of the skin beneath the heads of the second and the third metatarsals, indicating poor weight distribution in the forefoot. The distance from the anterosuperior spine to the floor on each side should be measured and recorded. This is to demonstrate congenital or acquired leg shortening.

Treatment. In the treatment of disability due to faulty weight-bearing, suitable shoes and arch pads should be prescribed. The shoes should have a broad heel, a long firm "counter" and, especially in women, a high vamp that can be laced securely. Arch pads glued into the shoes are preferable to the type that can be transferred from one pair of shoes to another. In any case, the pads should be made by an experienced bracemaker. When the plantar skin shows no calloused areas and no acutely tender spots, a pad of medium height should be centered beneath the scaphoid bone: this is a "medium scaphoid pad." When there is thickening of the skin beneath the head of the second metatarsal, the bracemaker should be instructed also to place a pad from $\frac{1}{8}$ to $\frac{3}{16}$ of an inch high directly beneath the head of the first metatarsal. This makes the head of the first metatarsal take a greater share of the weight and relieves the excessive pressure on the head of the second. In those patients who show no plantar skin thickening but complain of pain along the second to the fourth toes, a metatarsal pad placed just behind the heads of the second and the third metatarsals may be of value. If the measurement from the anterosuperior spine to the floor shows shortening of one leg, the heel should be raised on that side to compensate for it.

After the pads have been inserted and the heel has been raised as required, the patient is instructed to wear the shoes for a period of 5 days to a week and then to return for further inspection. Frequently, the pads need adjusting to suit individual

needs. In a large majority of cases, this form of conservative therapy will give complete and almost immediate relief, and most patients who once wear pads will not be without them.

Plantar Warts

Etiology and Diagnosis. Warts occurring on the plantar surface of the foot are among the frequent and painful lesions of this area (Fig. 463). Dermatologists believe that they are due to a type of virus; however, their appearance at sites of irritation is not infrequent. Often they are found to be associated with fallen arches. They occur more often in younger people, and they are important because of the *pain produced by pressure upon them.* Plantar warts may be small, or they may reach considerable size. Usually they are surrounded by an area of thickened epithelium, and in their center is a papillary growth that bleeds easily when it is pared with the scalpel. Pressure over this central core causes definite pain.

Treatment. There are several methods of treatment. The one probably that gives the least discomfort to the patient and, therefore, the least disability is roentgenotherapy. A competent roentgenologist or dermatologist should administer this, as there is considerable danger of overdosage, with disabling consequences.

Other methods of therapy are removal of the wart by electrodesicca*tion after anesthetization with pro*caine solution, the application of bichloracetic or trichloracetic acid or the application of carbon dioxide snow. In many cases, the wart disappears with a minimum of discomfort by the injection into its base of a drop or two of quinine and urethane solution. The wart becomes dark or black in a few days and peels out of its crater without difficulty. Suitable arch supports should be prescribed when necessary. Often this alone will effect a cure.

Callosities (Calluses)

Callosities are masses of hypertrophied epithelial tissue, hard and yellowish in appearance, which occur over areas subjected to long-continued pressure or friction. They are seen most commonly over the ball of the foot, and they arise in this area due to imperfect weight-bearing. Frequently they become tender and painful due to long-continued trauma.

Treatment. The treatment of cal*losities is removal of the cause. Since* there usually is defective weight-bearing, suitable arch supports must be prescribed. Little is gained by local therapy.

Bunions

Etiology. This is the name given to a hypertrophy of the metatarsophalangeal joint of the great toe. This joint becomes deformed with the wearing of shoes that do not fit properly and cause a lateral deviation of the great toe. As the joint becomes more and more prominent, pressure over the hypertrophied bone produces either a callus or a subcutaneous bursa. As the condition continues, the joint becomes painful, and frequently the bursa becomes the site of an in*fection (Fig. 464).*

Treatment. In the conservative treatment of bunions, attempts are made to reduce the deformity by placing a pad of lamb's wool between the great and the second toes and preventing pressure over the metatarsophalangeal joint *with felt pads. With* the wearing of shoes with toes that



FIG. 161. Typical deformity of a bunion. The photograph shows the infected callus over the prominence of the metatarsal head. The roentgenogram shows the marked bony deformity.

are wide enough, this may relieve the symptoms, but it rarely relieves the entire pathologic process.

Operation usually is necessary to produce a cure, and thus necessitates hospitalization.

PAINFUL HEEL

A heel that is painful in walking is a troublesome clinical entity for both patient and surgeon. This condition occurs in two groups of patients:

PAINFUL HEEL IN CHILDREN

Symptoms and Diagnosis. In the first group are the young children between 8 and 12 years of age, most of them boys. In this group there rarely is any history of injury, but the patient usually is active and vigorous. The pain is at the back of the heel; the patient walks with a slight limp and often notes that he is more comfortable when walking on his toes. On examination, the heel is found to be tender posteriorly with a slight thickening at the insertion of the Achilles tendon.

This symptom complex in children has been found to be due to an apophysitis of the heel. A lateral roentgen film shows definite changes in the region of the calcaneal epiphysis and the epiphyseal line.

Treatment. In milder cases, elevation of the heel with pads relieves the pressure on the Achilles tendon, and, by avoiding strenuous exercise, usually the symptoms disappear rapidly. Local heat in the form of foot baths may be of value. As a rule, the pain disappears spontaneously, but the patient should be warned that shoes with heels should be worn to avoid recurrence.

PAINFUL HEEL IN ADULTS

Etiology and Pathology. In adults, this lesion has been regarded as resulting from the development of a calcaneal spur. However, this finding in

the roentgen film probably is of no great clinical significance, and its presence appears to be incidental. Current belief is that the pain is due either to the development of a bursitis in the region of the spur or to a painful tension on the palmar fascia and the flexor digitorum brevis, which have their point of attachment near the site of the calcaneal spur. The pathologic process in this type of change may be similar to that which occurs at the external epicondyle in tennis elbow.

Treatment. In the treatment of painful heels in adults, various types of pads, springs and other devices to relieve pressure have been used, but usually without much success. Two methods of therapy are of value—injection and needling or actual division of the fascia and the muscles attached to the calcaneus.

In injection and needling, the painful area is infiltrated with 0.5 or 1 per cent procaine solution, and a large 14- or 16-gauge needle is introduced into the painful area. The needle is inserted from either side and passed a sufficient distance into the painful area to puncture and drain the bursa that may be present. In a fair percentage of cases, this results in a cure of the painful heel.

When injection and needling are not successful, a subcutaneous division of the fascia attached to the calcaneus in the region of the spur is performed under local anesthesia. A pointed knife is inserted, usually from the mesial side of the foot, and the tissues are divided. A pressure dressing is applied, and the part is elevated for a few days. Within 4 days to a week, the patient usually can walk without further pain.

PART THREE

THE MUSCULOSKELETAL SYSTEM

26

General Considerations

FRACTURES

DEFINITIONS

A *fracture* is an interruption of the normal continuity of bone or cartilage. It is an injury to a bone and, to a variable extent, also to the soft tissues surrounding the bone. A *dislocation* is a rupture of a joint associated with a persistent displacement of the bones entering the joint. A *subluxation* is a partial or an incomplete dislocation.

CLASSIFICATION OF FRACTURES

Fractures may be described and classified by certain characteristics. By a *simple fracture* is meant one in which the fracture site does not communicate with the outside air, the skin or the mucosa over the area being unbroken. A *compound fracture* is one in which such a communication exists, by way of torn skin or mucosa

Fractures may be classified as complete and incomplete. A complete fracture is one in which the entire thickness of the bone is broken through. In an incomplete fracture, part of the thickness is unbroken. Buckle, greenstick, depressed and fissure fractures are varieties of incomplete fracture.

A good description of the fracture line is helpful. The fracture line may be more or less transverse or oblique. When more than two fragments are present, it is called *comminuted*.

An *epiphyseal separation* is a fracture that occurs at the junction of an epiphysis and a diaphysis.

A *pathologic fracture* is one that occurs through a bone weakened by disease. It is suspected when a fracture occurs without the violence usually necessary to cause it.

PATHOLOGY OF FRACTURES

Fractures vary greatly in extent. A fracture may be only a simple fissure in a bone, or the bone may be shattered into many fragments. There may be little harm to the soft tissues about the bone, or there may be extensive lacerations and contusions of blood vessels, nerves, muscles and tendons.

A fracture may have both systemic and local effects. Pain, hemorrhage and exudation may lead to surgical shock. Locally, rupture of bone and soft tissues occur, with hemorrhage about the injured area. The local damage excites muscle spasm and vasomotor disturbances. Pain, tenderness, swelling and disability appear. After a few hours, there is an inflammatory reaction about the injured area, with exudation and increased swelling. The tissues may become tense, so that venous and lymphatic drainage is obstructed. The extremity swells at, and distal to, the site of fracture.

If the part is immobilized and ele-

vated, this acute inflammatory reaction to trauma subsides in a few days. If the part is not put at rest and is allowed to remain in a dependent position, the pain and the swelling persist for a longer period. Both the systemic and the local effects vary with the extent of the injury.

Process of Healing After Fractures

Rupture of blood vessels results in a hemorrhage about the site of a fracture, and a clot forms. The fibrinous network of the clot is invaded rapidly by fibroblasts and phagocytic cells, and there is an ingrowth of newly formed capillaries. This is the process that occurs in all wounds, so that the fibrin is replaced by new connective tissue and blood vessels, while the dead cells are removed by the phagocytes

Additional changes occur about a fracture. These changes probably are due directly or indirectly to the presence of living bone and osteogenic cells. From the sixth to the tenth day after injury, the organizing clot begins to show a change. The tissue characteristic of bone repair appears. This is called callus Cartilaginous areas, calcification and, later, ossification appear. The areas of ossification consist of irregular coarse spongy bone, which increase until the ends of the fragments are held together firmly. This primary callus is replaced gradually by true bone, which at first is spongy. Later it becomes dense, new bone being laid down along the lines of stress and strain. Simultaneously, there is a resorption of excessive callus and of excessive bony prominences of the fragments to as to re-form more or less the normal axis and contour of the bone. This process continues over a period of several years.

Delayed Union and Nonunion

Bony union tends to occur in all fractures under favorable conditions. The rapidity with which it occurs is influenced by many factors, such as the age of the patient, the blood supply of the fragments, the site and the type of the fracture, and the state of nutrition. Fractures unite rapidly in the young and rather slowly in the aged. The blood supply of the fragments and of the tissues about the fracture may be affected in severe injuries. When the soft tissues have been crushed extensively and when the blood supply of the fragments is meager, union may progress very slowly.

The site of fracture is important in relationship to the blood supply. The expanded spongy ends of the long bones are quite vascular, so that fractures in these areas, such as the head of the humerus, the lower end of the radius and the upper end of the tibia, usually unite rapidly and firmly. The dense shafts of the long bones have a relatively poor blood supply, and even this may be diminished by a stripping up of periosteum and injury to the nutrient arteries. Therefore, fractures of the shafts tend to unite slowly.

There is considerable evidence to show that stimulation of the blood flow to the fractured part hastens union. The most effective means of increasing the blood supply to a part is by active function, hence the value of immobilizing a fracture in a dressing that will permit function.

The general state of nutrition conditions the process of union. A diet low in calcium and deficient in calories and vitamins, especially vitamins C and D, may be a cause of less rapid union than normal. However,

there is no clear evidence to indicate that an excess of these elements will cause union to occur more rapidly than normal.

When a large gap occurs between the fragments and when soft tissues are interposed, union may progress slowly, or it may be prevented entirely.

In some instances, a major fragment may be deprived entirely of its blood supply, as in a fracture of the carpal navicular. In such fractures union occurs slowly. Infection of the fracture site, even when slight, commonly delays union to some extent, and union may be delayed considerably when osteomyelitis is present.

The most important cause of delayed union and of later nonunion is inadequate immobilization. Motion of one fragment on another may cause repeated rupture of growing blood vessels and young fibrous tissue. Excessive fibrous repair follows, and the formation of new bone is hindered. When this process continues, union may be prevented entirely. This condition is particularly likely to occur in the shafts of the long bones when they are subjected to shearing strains before union is firm.

Clinical Signs of Union

When a fracture has united firmly by callus, the callus may be palpable as a fusiform, smooth bony thickening about the fracture site. Previously palpable rough edges of bone lose their prominence. The local tenderness over the fracture site disappears. The bone can be felt to have normal rigidity when tested cautiously. When use is resumed without support, there should be no pain at the fracture site. A recurrence of pain and tenderness suggests that union is incomplete and longer immobilization is advisable.

Nonunion

Nonunion of a fracture is said to be present when the process of healing comes to a standstill before union occurs. The factors that cause delay in union may cause failure of union. When the delay in union is prolonged and when repeated roentgenograms over a period of months show increasing density of the bone ends and no new bone formation between the ends, the state of nonunion is present.

DIAGNOSIS OF FRACTURES

The diagnosis of fractures and dislocations is based on the history of injury, the patient's complaints, the findings on physical examination and the roentgen examination.

History

The history of a characteristic injury often leads the surgeon to a correct diagnosis. For instance, a history of injury to the wrist followed by persistent pain should lead to repeated examinations for fractures in this area.

Complaints

The location of pain and the character of disability often suggest the correct diagnosis.

Physical Examination

The classical signs of fracture are swelling, ecchymosis, deformity, localized tenderness, abnormal mobility and crepitus. In many instances, the diagnosis is simple, since swelling and deformity are visible; nevertheless, a careful examination must be made. Additional fractures and serious injuries to blood vessels, nerves and the muscular apparatus may be present. Sensory, motor and vascular changes, or their absence, should be recorded.

The injured side must be compared

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at this time. Temporary splints for transportation are described under the individual fractures.

Evaluation of Displacements

The roentgenograms must be inspected to determine the degree of displacement of the fragments. Many slight or moderate displacements have no effect on the appearance or the function of the part after union occurs, and in these instances no reduction is required. Displacements that will affect the appearance or the function of the part must be corrected as promptly as possible.

In patients of advanced age and in those who suffer from constitutional diseases that make the induction of anesthesia hazardous, the advantages to be gained from reduction must be weighed against the risk involved.

In patients of advanced age, prolonged bed rest also has adverse effects, so that suspension and traction methods of reducing and immobilizing fractures suffered by them entail risk. In many of these patients considerable displacement may be tolerated in order to secure the advantages of ambulatory treatment.

Anesthesia for Reduction of Fractures and Dislocations

In many reductions, either local or general anesthesia may be used, but we believe that, whenever possible, local anesthesia is to be preferred. Its advantages are many. Its toxic effect is low. Good relaxation may be obtained without the unconsciousness of deep general anesthesia. The patient is awake and can co-operate with the surgeon. Many patients have full stomachs and are likely to vomit during general anesthesia, with the danger of aspirating the vomitus. The effect of local anesthesia often lasts an hour or more, thus permitting more gentle and leisurely manipulations, easier application of plaster and dressings, and even repeated maneuvers, when necessary, without inducing additional anesthesia.

However, in very young children, local anesthesia is unsatisfactory. It is also likely to be unsatisfactory when the fracture is more than 2 or 3 days old, when a clot has formed and has begun to organize, diffusion of the anesthetic is poor, although the addition of hyaluronidase to the anesthetic solution may overcome this difficulty.[5]

Reduction of Displacements

The surgeon should make every effort to obtain favorable conditions for reduction. These are: (1) adequate roentgen study prior to reduction; (2) facilities for roentgen study during or immediately after reduction; (3) adequate anesthesia; (4) adequate apparatus for reduction; and (5) proper immobilizing devices, such as splints or plaster.

The technic of most manipulative reductions usually is simple. Sufficient traction is made to overcome overlapping of fragments. While the traction is maintained, the fragments are placed in correct position by direct pressure.

The traction for reduction must be made in a slowly increasing manner, without abrupt pulling or jerking. When the shaft of a long bone is involved, 5 to 10 minutes, or even more, of steady traction may be required before the shortening is overcome and replacement can be attempted. When the maneuvers are finished and the fragments are immobilized, a roentgen examination must be made to determine whether or not reduction is com-

with the uninjured side, with particular reference to visible or palpable deformity and points of tenderness. These are the most important signs. Deformity may present itself as a shortening, an angulation or a rotary shift in axis. It may be palpable only as thickening or irregularity of a bony contour, and this may become evident only when the normal side is used for comparison.

Well-localized acute tenderness over one part of a bone strongly suggests a fracture, even in the absence of other signs. This is a most valuable sign in simple fractures without displacement or deformity, as is also gentle percussion in the long axis of the suspected bone.

Crepitus and preternatural mobility rarely need to be elicited. Making one fragment grate on the other for crepitus or for determination of abnormal mobility invites the risk not only of displacing fragments but also of lacerating vessels and nerves by sharp bone ends

Roentgen Examination

In many instances, when the only signs of fracture are swelling and localized tenderness, roentgenograms must be made for diagnosis. Under some conditions, failure to demonstrate a fracture in the films does not exclude one until additional films are made after 2 or 3 weeks. Epiphyseal separations without displacement and fractures of the carpal navicular belong in this class.

Even when the diagnosis is certain, roentgenograms must be made before an attempt is made to reduce either fractures or dislocations. The films should include the joint nearest the fracture; when the degree of angulation of fragments is in doubt, they should be even longer. Views in at least two planes at right angles to each other are necessary. Often supplementary views are required. When a reduction is to be performed, the films should be placed where the surgeon can see them during the manipulations.

Fluoroscopic examination only, without films, is unsatisfactory for diagnosis. Many small fractures may be missed, and the necessary details concerning obliquity or comminution of the fracture cannot be obtained. Fluoroscopic examination is a valuable supplement to films, not a substitute for them.

PRINCIPLES OF FRACTURE TREATMENT

The goal in treating fractures and dislocations is the restoration of the patient and the injured part as nearly as possible to their uninjured state. The fragments must be replaced in their normal position and held there until bony union has taken place. Both function and appearance must be considered.

Compound fractures are major surgical emergencies that require immediate hospitalization and operation. They are not suitable for ambulatory treatment except when phalanges or toes only are involved.

Prevention of Shock and Additional Injuries

Shock often can be prevented by proper treatment. Careful transportation is of major importance. No patient with a fracture should be moved until the injured part has been splinted adequately. This relieves pain, prevents additional injuries and displacements, and helps to prevent shock. The use of sedatives is valuable



Fig. 465. Cast cutters and plaster knives.

ferred. In some instances, plaster substitutes have certain advantages.

An adequate armamentarium for a physician's office includes:

6 board splints, 3 x 36 x 1/4 in., for immobilization of leg fractures
12 board splints, 3 x 21 x 1/4 in., for ankle fractures
12 board splints, 3 x 18 x 1/8 in., for wrist fractures
6 internal right-angled splints, assorted large, medium and small
6 curved wood posterior knee splints
3 feet of 1/8 in. iron wire (coat-hanger wire will do)
1 doz. plaster bandages, quick setting, 2 in. wide
1 doz. plaster bandages, slow setting, 4 in. wide
1 doz. plaster bandages, slow setting, 6 in. wide
(the recently introduced resin plaster of Paris bandage (such as Melmac) has advantages over the ordinary type).
1 sq. yd. white or gray felt, 1/4 in. thick
Cardboard for shoulder caps
Adhesive, bandages, absorbent cotton, rubber tubing, stockinet, all sizes
Webbing straps, 4 in. wide
Mastisol—Rx Gum mastic 20 Gm.
Chloroform 50 cc.
Linseed oil 20 drops
Scissors, cast cutters, saw, pliers, plaster knife (Fig. 465)

Preparation for Splints and Casts

The part to be encased in a splint or a plaster dressing must be cleansed. Grease and dirt are removed with waste ether or benzene, and the part is mopped with alcohol and allowed to dry. When adhesive is to be applied to hairy skin, it is advisable to shave the part and paint it with compound tincture of benzoin. Thus, discomfort and dermatitis can be prevented to a considerable extent.

Most casts for the upper extremity are applied without padding. The plaster sticks to the skin and does not irritate it. When the patient is to walk on a plaster cast applied to the lower extremities, felt padding is incorporated at the weight-bearing points, such as the tuberosities of the tibia or the tuberosity of the ischium.

Wood Splints

Wood splints must be trimmed to proper length and width before application. When the splint is to be applied to a uniformly flat surface, such as the dorsum of the forearm and the wrist, fluffy absorbent cotton is placed 1/2 in. thick on one side of the splint and bandaged evenly and lightly to it. When a splint is to be applied to a curved surface, such as the flexor surface of the forearm or the knee, the padding is applied more thickly where the splint lies against a concavity; this makes the surface of the splint conform to the shape of the part. The

plete and satisfactory. When good replacement has not been obtained, reduction, immobilization and roentgen examination must be repeated. What is meant by good replacement is a position close enough to normal to give a good functional and cosmetic result.

Immobilization

The fracture must be immobilized adequately for a sufficient length of time. Requirements for specific fractures will be described later.

General Rules for Immobilization. When a splint or a cast does not fit well and does not include a sufficient length of the extremity on both sides of the fracture site, excessive motion may occur. Adequate immobilization for a fracture in the shaft of a long bone requires immobilization of the joints proximal and distal to the fracture site. When the fracture lies in the spongy end of a long bone very close to a joint, as in fractures of the head of the humerus and the lower end of the radius, immobilization may be adequate when it extends sufficiently to immobilize the joint. When small fissure fractures and avulsion or sprain fractures are close to the joints, often they may be treated in the same way as sprains.

A splint or a cast must remain on the part without interruption for a sufficient length of time. When immobilization is discontinued prematurely, the process of healing may be interrupted.

Effect of Immobilization on the Soft Parts. When an entire extremity is immobilized, characteristic changes occur. Muscle spasm, vascular disturbances and immobilrty lead to a diminished blood supply and diminished venous and lymphatic drainage. These lead to atrophy of muscles and contracture of ligamentous tissues The fibrosis that follows the inflammatory reaction to trauma may cause joint, muscle and tendon adhesions. The part becomes weak and painful. Disturbed vasomotor regulation causes marked edema when the part is dependent.

These adverse effects on the soft parts are largely preventable. The immobilization of the fracture should be sufficient but not excessive in extent. Every muscle and joint that can be exercised without disturbing the fragments should be exercised from the beginning. The policy of waiting until a splint or a cast is removed before any activity of the part is begun is to be deprecated In many fractures, the active use of the extremity may be regained to a considerable extent as soon as the acute reaction to trauma subsides, or as soon as an accurately fitted unpadded cast is applied. If the part is used actively, the vasomotor disturbance subsides rapidly, and the muscle contractions stimulate circulation and increase venous and lymphatic drainage. Less exudate remains for organization into fibrous tissue, and motion prevents this fibrous tissue from forming troublesome adhesions.

Materials for Fracture Treatment

For the first-aid and preliminary treatment of many ambulatory patients, wood splints, adhesive and bandage dressings are very satisfactory. The wood splints can be made comfortable by proper padding, and they are effective as temporary dressings They cast no confusing shadows in the roentgenograms.

For the more permanent dressings, plaster of Paris splints or casts are pre-

Aftercare of Fractures

In the case of muscles that are capable of being exercised, this should be done from the beginning. After the immobilizing dressing has been removed, a supportive dressing often can be used to great advantage. This is particularly applicable to the lower extremity, which edema tends to occur for some time. A gelatin boot or an elastic adhesive bandage can be applied from the toes to the knee and remain for from 3 to 4 weeks. After extensive injuries and in aged, nephritic and cardiac patients, such a dressing may be needed for several months. The common elastic bandage is not satisfactory on the leg. It loosens, slips and curls, and it may increase rather than decrease swelling.

Formal physiotherapy, such as diathermy, baking and massage, is not required frequently after fractures in ambulatory patients. If the part is exercised properly, there will be very little stiffness when a cast is removed. When stiffness and discomfort are present, home physiotherapy is prescribed individually. Exercises are designed to increase the flexibility and the tone of particular muscles and joints. When possible, some form of useful occupational exercise is devised for the patient. The exercises are performed with increasing frequency. To increase circulation and flexibility, the part can be immersed in hot water for from 10 to 15 minutes. This is followed by a mild massage with alcohol or an ointment of 10 per cent methyl salicylate in petrolatum. The patient can give himself a treatment 2 or 3 times daily.

EPIPHYSEAL SEPARATIONS

Definition

From infancy to adolescence, the long bones of the extremities are particularly vulnerable to acute trauma at the points at which growth is taking place. This is due to the structural peculiarities about the epiphyseal cartilage, which lies between the epiphysis and the diaphysis at each end of a long bone. Such epiphyseal injuries usually are described as epiphyseal separations with or without displacement. they really are complete or partial fractures through the bone just on the diaphyseal side of the epiphyseal cartilage. Much less frequently, fractures of the diaphysis are seen that extend through the epiphyseal cartilage and through the epiphysis itself.

In a true traumatic epiphyseal separation, there is a clear-cut history of an adequate external violence to a previously normal structure. This clinical picture should be distinguished from that of a pathologic epiphyseal separation in which a slight, and ordinarily inadequate, trauma causes displacement of an epiphysis because of infections or dystrophic changes in the epiphyseal area. The difference is analogous to that between ordinary and pathologic fractures. In the class of pathologic separations belong the spontaneous separations, slipping epiyhyses and displacements during osteomyelitis and other diseases.

Normal Anatomy

In early infancy, a long bone consists of a bony diaphysis with a purely cartilaginous epiphysis at each end. Roentgen films of such a bone show the radiopaque diaphysis, but nothing of the entirely radiolucent epiphysis. Some time during infancy a center of ossification appears in the epiphysis. This continues until, later, the whole epiphysis is visible in the films. It re-

splint or splints must be secured to the part with wide (2 or 3 in.) adhesive straps, when possible. The wide straps are convenient for the leg and the forearm; 1-in. straps are used over the hand.

Plaster Splints and Casts

Ready-to-use plaster of Paris bandages now are available. These can be used to make almost any type of splint or cast. When a choice can be made between slow-setting and fast-setting plaster bandages, the former usually are preferred, since they allow more time to mold the dressing to the shape of the part before it becomes hard. Relatively few accessories are needed for good plaster work. A smooth glass, an enamel or a stainless-steel surface should be available for making plaster splints.

The ends of the paper that is wrapped about the prepared plaster bandage are opened, and the bandage is placed on its end in a basin of cold or lukewarm water. When the air bubbles have stopped rising, the bandage is saturated. The paper wrapping is removed, and the bandage is ready for use. To make a plaster splint, the plaster bandage is rolled out to the desired length and then rolled back, the surface being rubbed to make the two pieces hold together. This is repeated until a sufficient thickness is obtained. The splint is applied to the part, molded evenly to avoid creases, and secured with gauze bandages. Most casts are made by applying first one or more splints. These are secured with plaster bandages, not gauze. The circular turns of plaster must be applied with care to avoid tension, excessive pressure, creases and indentations. When a sufficient thickness has been applied, the plaster is rubbed firmly to make the separate layers adhere to each other. In addition, the plaster is molded with even pressure about the bony landmarks. While the plaster hardens, the part must be supported with particular care to avoid indentations. All rough edges or unnecessary projections are trimmed off with scissors or a plaster knife before the plaster is completely hard. The cast does not acquire its full rigidity for a few hours. During this time the part is kept quiet.

The patient is seen the day after the cast was applied. Persistent pain beneath it suggests a pressure point, and the cast may be split, or a window may be cut in it. Cotton is applied if necessary, and the cast is repaired with a plaster bandage; otherwise, there will be edema at the window or the splitting point.

Casts on the upper extremity must extend to the distal ends of the knuckles to avoid edema of the hand. Similarly, casts on the lower extremity must extend to the webs of the toes on the dorsum and slightly beyond the toes on the plantar surface.

Plaster Compounds and Substitutes for Casts

Casts may be made of materials other than ordinary plaster. Plaster of Paris bandage compounded with a plastic resin has advantages over ordinary plaster of Paris: it resists water and body secretions. Its higher strength permits lighter and thinner casts.

Small casts may be made of gauze and a solution of sodium silicate. The part is bandaged with gauze, which then is saturated with warm sodium silicate solution. As the solution dries, the dressing becomes hard and rigid

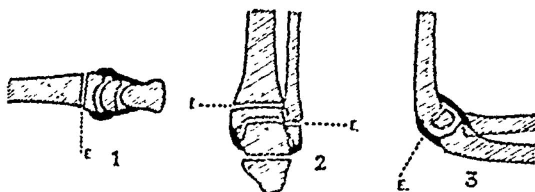


FIG. 167. Extra-articular epiphyseal cartilages 1, at the lower end of the radius; 2, at the ankle Intra-articular epiphyseal cartilages 3, at the elbow. E, the epiphyseal cartilage. (Kaplan, Louis S Clin North America 17:1637)

end of the humerus, the epiphyseal line lies partly within and partly outside the joint.

The periosteum is bound down densely at the epiphyseal line. When the epiphysis separates and moves on the diaphysis, the periosteum tends to go with the epiphysis, denuding the shaft of part of its periosteal sheath. When reduction is attempted, the periosteum may fold in and interpose itself between the fragments. If the displacement remains, later bone growth occurs in the periosteal sheath, and any protruding portion of the diaphysis usually is absorbed.

Mechanism Producing Separation

In the large majority of cases, the separation is produced by an indirect mechanism. The trauma, applied to the shaft of a long bone, tends to carry a joint movement beyond the normal limit, causing traction on the ligaments on one side of the joint while the structures on the opposite side are compressed.

Symptoms and Signs of Epiphyseal Separation

In infants and very young children, no history of injury may be elicited. The child may fall from a chair or a crib in the absence of the parents, and the incident may not be reported by the person in charge The parents may note that the child suddenly has stopped using an arm or a leg, that motion of the extremity causes pain, or that a swelling suddenly has appeared about one of the joints. Examination usually discloses swelling about a joint, sometimes with ecchymosis. When the separation is complete, visible deformity and mushy crepitus may be present, making the diagnosis obvious, or the separation may be incomplete and evidenced only by sharply localized tenderness over the epiphyseal cartilage in addition to the swelling

In older children, the history of trauma usually is clear. Following a blow, a jump from a height, or a fall while running, there is pain well centered in the epiphyseal area. When the separation is incomplete, the immediate pain may be very mild. These children usually complain of persistent soreness close to a joint and sometimes recall the trauma only with difficulty. The clinical diagnosis must rest on the presence of sharply localized wincing tenderness at the epiphyseal line, accompanied by swelling and perhaps ecchymosis.

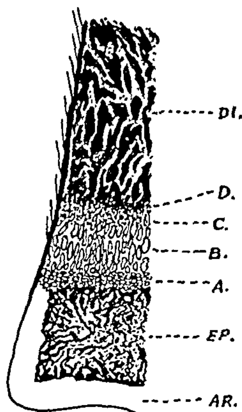


FIG 466. Diagrammatic representation of the anatomy of the epiphyseal cartilage. (A) A layer of elastic cartilage which forms new cartilage cells continuously on the side toward the diaphysis. (B) These cartilage cells have arranged themselves into longitudinal columns. (C) Area of beginning calcification (D) Bone formation (AR) Articular cartilage. (EP) Epiphysis (DI) Diaphysis (Kaplan, Louis: S. Clin North America 17:1637)

mains clearly demarcated from the diaphysis by a layer of elastic tissue, the epiphyseal cartilage. Bone growth takes place from the diaphyseal side of this cartilage, and, while the growth continues, the area remains radiolucent. When growth ceases, the cartilage ossifies, and the epiphysis fuses with the diaphysis. The time for this differs for the various epiphyses, and, to some extent, it varies for different persons; in general, it is during adolescence.

Diagrammatically, the region of growth between an epiphysis and a diaphysis may be considered as having four planes, as shown in Figure 466: (A) a layer of elastic cartilage that forms new cartilage cells continuously on the side toward the diaphysis; (B) these cartilage cells have arranged themselves into longitudinal columns; (C) a little farther away from the epiphysis, the columns of cells show invasion by small blood vessels and beginning calcification; (D) in the last area, the calcified cartilage is being converted into typical haversian bone. The area C-D appears to be most vulnerable to trauma. This partly calcified tissue no longer has the elasticity of cartilage, it lacks the strength of true bone, and it is at this level that most separations occur. Unless there is actual crushing of the whole thickness of the cartilage, injury at this level does not affect the growth area A-B, which is elastic and receives its blood supply from the epiphyseal vessels.

The relation of the epiphyseal line to the joint space is important, because the point of attachment of capsular and other ligaments has a definite bearing on the mechanism of separation (Fig. 467)

The epiphyseal cartilage may be extra-articular or intra-articular, or both, in parts The epiphyseal lines at the lower ends of the radius and the ulna, or the tibia and the fibula and of the femur are wholly extra-articular, the capsular and other ligaments having their insertion only on the epiphysis. The epiphyses at the elbow and at the neck of the femur lie entirely within the joints and bear little or no ligamentous attachment. At the upper

is of importance, particularly at the wrist and the ankle, when one of the two epiphyses separates while the other is uninjured. Failure of growth in one and normal growth in the other may result in marked deformity.

Only rarely does an increase in length follow epiphyseal injury.

CONTUSIONS

Pathology

Injury to the tissues caused by crushing or bruising violence is known as contusion. Such wounds may be open or closed; this discussion is limited to closed wounds. Although the skin may not be broken, there may be extensive damage to underlying muscles, tendons, blood vessels and nerves, with little or great devitalization of these tissues, depending on the force of the impact and the region of the body involved. Blood vessels are ruptured, and there is hemorrhage into the tissues. There also is considerable exudation in response to tissue damage. These two factors cause the swelling and the discoloration that characterize contusions. The rather severe pain is due to tissue damage and increased tissue tension and, later, to the inflammatory reaction about the devitalized tissue and blood clots.

The late effects of untreated contusions may be troublesome. There is an inflammatory reaction in the injured area. The dead or damaged tissue cells are replaced by fibrous tissue. The blood and the exudate in the tissues are absorbed to some extent and organized to a considerable extent, with further fibrous tissue formation. As a result, skin, fascias, muscles and tendons may become adherent to one another, with corresponding impairment of function.

Treatment

During the acute phase of hemorrhage, exudation and inflammatory reaction, which lasts a few days, treatment aims at relief of pain, prevention or dispersal of hemorrhage and exudate, and immobilization of the tissues to facilitate healing of torn structures. When the acute phase subsides, treatment aims at prevention of dense fibrosis and tissue adhesions and early restoration of function.

Immediately after the injury, the essential points in treatment are rest and elevation of the part, the application of a pressure dressing, and the use of ice bags over the affected area. Rest and elevation diminish the pain, facilitate venous and lymphatic drainage, and expedite healing. A pressure dressing helps to reduce the swelling if it has appeared already. Ice bags are helpful during the first 48 hours after injury; the cold diminishes pain, and it seems also to diminish the inflammatory reaction in the affected area. After 3 or 4 days, when the acute reaction has subsided, heat and massage accelerate absorption of fluid and cellular exudate. Active use of the extremity is begun as soon as possible to avoid the formation of adhesions.

Contusions of the head and the neck are treated by the application of ice bags, which exert some pressure effect in addition to cold. If large hematomas are seen early, aspiration may be attempted.

In the shoulder and the arm, strapping with adhesive plaster or elastic adhesive bandage and the use of a sling are indicated for extensive injuries in addition to the other measures.

In the forearm and the hand, a splint and a pressure dressing of flannel or elastic bandage are indicated.

Roentgen Evidence of Epiphyseal Injury

Before a center of ossification appears in a given epiphysis, the only roentgen evidence of epiphyseal separation with displacement may be a change in the alignment of a diaphysis *with regard to its neighbor.* Frequently, however, a small chip fracture of the diaphysis at the epiphyseal line will give positive evidence of injury.

Even after a center of ossification appears in the epiphysis, if the fracture runs through the radiolucent epiphyseal line alone and there is no displacement, films will show nothing. An associated chip fracture of the end of the diaphysis or a fissure in the epiphysis should be sought. Comparison with the opposite normal side may disclose widening or narrowing of the epiphyseal line or slight lateral displacements.

Although no roentgen evidence of epiphyseal separation may be present at the time of injury, it may be present later Bony repair begins at the point of injury, and calcification may extend along the elevated periosteum. After a period of 3 or 4 weeks, calci*fication may be visible, indicating the* site of injury.

Pure epiphyseal separation without displacement gives no roentgen sign; therefore, it is not excluded when the report of the roentgenogram is negative.

An epiphyseal separation is treated as is the equivalent adult fracture.

Effect of Epiphyseal Injury on Bone Growth

Epiphyseal injury results frequently in some disturbance of bone growth, as seen in later roentgenograms; Compere[2] noted this in 18 of 19 cases. The appearance of disturbed bone growth may be long delayed. Follow-up examination is necessary for a considerable period. The development of deformity may require operative correction.[9]

Failure to reduce displacement is not a cause of arrest in growth In many cases in which reduction is incomplete, later active bone growth pushes the diaphyseal site of separation farther and farther away from the epiphysis, while in others without any displacement whatever there is later failure of osteogenesis.

The structure of the epiphyseal cartilage explains this to some extent. Ordinary separation may be represented as an injury in which the epiphysis is torn away from the diaphysis at the level of calcifying cartilage, with little or no damage to the actively proliferating cells of the elastic layer below. When the epiphysis is crushed or impacted against the diaphysis, the whole thickness of the epiphyseal cartilage between the two may be damaged, the actively proliferating side of the cartilage suffering as much as the calcifying side. When a fracture extends through the epiphysis, growth disturbance is likely. Microscopically, cases of arrest in growth are said to show diminution of the number of actively proliferating cartilage cells in the epiphyseal side of the cartilage and failure of these cells to arrange themselves in characteristic rows.

Clinically, there seem to be no signs by which the damage to the epiphyseal cartilage itself can be determined, hence there are no signs by which the prognosis for growth can be judged, except when the fracture extends through the epiphysis. This

Actual laceration of a ligament can be inferred only when the involved ligament is made tense and then is found to stretch beyond the normal limits. Digital pressure on the stretched ligament may disclose lack of resistance as compared with the normal side. Because of the severe pain that they cause, these procedures cannot be performed adequately unless the ligament involved is infiltrated with procaine solution. Anesthetic infiltration of the ligaments involved should be part of the diagnostic procedure. Freedom from pain and muscle spasm is essential for a thorough examination.

In many instances, swelling and diffuse tenderness make it difficult to exclude fractures. Early roentgen examination is indicated whenever fracture is suspected. For instance, sprains of the internal lateral ligament of the knee often are complicated by lacerations of the crucial ligaments or avulsions of the tibial spines into which they insert.

Treatment

The traditional treatment of simple sprains is based on the assumption that all are gross injuries to ligaments. Immobilization in the position in which the ligament is relaxed facilitates healing and relieves pain. A pressure dressing prevents or diminishes swelling. Rest and elevation also help to control pain and swelling. Ice bags help to relieve pain in the first 24 to 48 hours after injury. The part is used as little as possible until the acute symptoms subside, then heat and massage are prescribed to obtain early return of function.

When a simple sprain is present, without rupture of ligaments or avulsion of bone, the tender area is infiltrated with procaine solution, if this has not been done already for diagnosis. After infiltrating the area of most acute tenderness with from 5 to 10 cc. of 1 per cent procaine solution the joint is moved about to find any other painful areas and is palpated for additional tenderness. Any such secondary areas also are injected with from 5 to 10 cc. of solution each. No immobilizing dressing is applied if swelling is slight, and the patient begins to use the extremity immediately. There is likely to be a recurrence of pain after several hours, and in exceptional instances this may be very severe. This recurrent pain subsides after a few hours. A second procaine infiltration is given in 24 hours, unless there is no pain. Very often no further infiltrations are necessary. About 10 to 15 cc. of procaine solution, 1 per cent in distilled water, without epinephrine, is used for each infiltration about the ankle and the knee joints, less is used about the smaller joints. The addition of hyaluronidase, 1000 turbidity reducing units, to 5 cc. of 1 per cent procaine solution has helped to increase anesthesia and disperse swelling.[6] The disability caused by simple sprains often is remarkably short with this method of treatment, which stops the afferent impulses from the injured area so that the vicious cycle is interrupted. If there is considerable swelling, an elastic bandage is used.

If there is a slight tear of ligaments, the joint is immobilized in a position that relaxes the ligament involved. Adhesive strapping often is adequate; splints seldom are required. The immobilization is continued for from 2 to 4 weeks. Demonstrable gross rupture of a ligament constitutes a much more serious injury.[3]

When bone has been torn away and

For contusion in the back (p. 351), adhesive strapping is used for immobilization in addition to the other measures.

In the lower extremity, strapping or elastic adhesive bandage, or both, are used for immobilization and pressure.

SPRAINS

When a joint is twisted or forced abruptly to its limit of motion, a characteristic form of injury known as a sprain occurs. The ankle, the knee and the finger joints suffer most frequently.

Symptoms

There is brief excruciating pain at the moment of injury, followed by a severe aching pain that may persist for many days. Motion of the joint aggravates the pain, and the patient may not be able to use the part. The area involved becomes extremely tender, swells rapidly and later exhibits ecchymosis. The local temperature rises, and muscle spasm appears.

Pathology

Sprains usually have been considered to be partial or complete lacerations of ligaments due to overstretching. When the ligament is torn from its bony insertion, it may take with it a portion of bone. This is known as a sprain fracture Hemorrhage, exudation, pain and disability have been attributed to lacerations of ligaments and soft tissues.

Long ago Leriche[4, 5] took issue with this traditional view of sprains and offered considerable evidence in favor of another conception. He believed that sprains were local functional circulatory disturbances of traumatic origin. He classified these lesions into 3 groups: (1) simple sprains; (2) sprains complicated by laceration of ligaments; and (3) sprains complicated by avulsion of bone.

It has been demonstrated that ligaments are richly supplied with nerve endings. Leriche believes that simple sprain is due to an abrupt excitation of or injury to these endings, caused by violent torsion or stretching of the ligaments involved. Afferent impulses then bring into play efferent sympathetic impulses. There is a transient vasoconstriction followed by vasodilatation. Pain, effusion and functional disturbance are attributed to the vasomotor disturbances. Effusion and disturbed blood supply further stimulate the nerve endings, and a vicious cycle is established. Others express the opinion that the local disturbances are due in part or completely to axon reflexes The vasomotor equilibrium usually is re-established in from 8 to 10 days. In exceptional instances, it may be persistent and the cause of chronic sprain. Leriche maintains that "pure sprain" may, and often does, exist without macroscopic ligamentous lesions He considers lacerations of ligaments and avulsion of their bony insertions as complications that make the prognosis less favorable but do not influence the symptoms essentially.

Diagnosis

Following violent twisting or stretching of a joint, there may be marked pain, disability and functional disturbance. It is important to determine if gross laceration of ligaments or avulsion of the bone has occurred.

In simple sprains, the tenderness is well localized over the involved ligaments, and there is not marked tenderness of their bony insertions. Acute tenderness over the bony insertions indicates possible sprain fracture and should lead to roentgen examination.

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a sprain fracture is present, Leriche advises operative fixation or excision of the fragment, unless displacement is slight or absent.

During the war years, the use of local anesthesia in the treatment of sprains and contusions gained considerable popularity.[1,8] Ethyl chloride spray[7] of the skin over the painful area has been used in much the same way as the local anesthesia injection, also with good results. The spray is used until the skin is white, but caution must be exercised to avoid frost bite.

Summary

The procaine infiltration treatment of simple sprains shortens the disability remarkably in many cases. Often it can be supplemented to advantage by local support, such as strapping and pressure dressings. Repeated procaine infiltrations of sprain fractures has shortened the disability in many of these lesions also.

For treatment of specific sprains, see the section on the anatomic part concerned.

STRAINS

Pathology

The term *strain* usually has been applied to a muscular injury sustained by sudden forcible contraction or by sudden violent stretching. The origin, or insertion, of a muscle usually is the site of the injury, less often the belly of the muscle is involved. The actual lesion is thought to be a rupture of some fibers of the aponeurotic origin, or insertion, or of muscle fibers themselves, but no gross rupture is palpable or visible. Actual macroscopic rupture of muscles is a different condition and is described elsewhere. *Strain* may bear the relationship to muscles that sprain bears to ligament.

Symptoms

Pain and disability are sudden immediately after the violence. The pain may abate for a short time and be replaced by an ache localized over the site of the injury. Swelling, diffuse local tenderness and muscle spasm appear. Ecchymosis is rare. Contraction of the muscle involved increases the pain.

Diagnosis

Usually there is a characteristic history followed by typical symptoms. The site of injury is tender and swollen. Contraction of the muscle against resistance increases the pain. The back and the shoulder muscles often are involved, the thigh and the leg muscles less frequently. When gross rupture of a muscle belly or an insertion occurs, there is loss of power, contraction of the muscle produces a striking bulge of the muscle belly close to the less-injured end.

Treatment

Rest, immobilization and pressure dressings are the essential points of treatment. Ice bags are useful in the first 24 to 48 hours after injury. After the acute symptoms subside in 4 or 5 days, heat and gentle massage may give earlier return of function. Rest and immobilization usually are obtained by adhesive strapping applied so as to keep the injured muscles relaxed (Fig 491). When the muscles of the extremities are involved, an elastic adhesive bandage may be applied to make pressure, control swelling and provide additional support.

In many instances, procaine infiltration of the areas involved has shortened the period of disability remarkably. It is used repeatedly, if necessary, as described under Sprains



FIG. 468. Adhesive strapping for fractures of the lower ribs or costochondral separation at the costal margin. Circular straps first are applied, overlapping in front and followed by the vertical straps on the affected side. Additional circular straps then are applied, overlapping on the back.

one or two ribs when it may entail hardship for the patient. However, when any medicolegal aspects are present, it is well to have the examination made as a record of the injury.

Treatment. No reduction is attempted. The patient with an uncomplicated fracture of the ribs requires primarily relief of pain. This may be obtained by strapping the chest and administering liberal doses of codeine and acetylsalicylic acid during the first few days. When pain is severe or when there are multiple fractures, bed rest must be insisted upon for a period of 1 to 3 weeks or more. Injection of 10 to 20 cc. of 1 per cent procaine solution directly into the fracture site and/or into the intercostal nerves along the lower border of the fractured and adjacent ribs often gives prolonged relief of pain. This may be repeated several times if necessary.

The ordinary semicircular strapping of the chest is inefficient at its best, it loosens rapidly, and the tension on the skin frequently causes blebs. Complete circular strapping, with the tension adjusted just enough to immobilize the ribs but not tight enough to choke the patient, gives greater relief and less trouble. For the upper ribs, the circular adhesive may be reinforced by vertical straps (Figs. 468-470), crossing the shoulders from back to front. Giving the skin a good alcohol rub and covering hairy areas with gauze help to avoid pustular adhesive dermatitis. Tincture of benzoin often may be used to protect the skin. After measuring the circumference of the chest below the fracture level, tear off three or more slightly longer straps of adhesive from 2 to 3 in. wide. With the arms elevated, the patient takes a deep breath and exhales fully; then, starting in the anterior mid-line well below the level of the fracture, the strap is carried round the unaffected side to the back and forward over the affected side, the starting point finally being overlapped. The next strap is applied higher, half of the width of the first strap being overlapped. This is continued until the highest strap is two or three ribs above the fracture site. When the upper ribs are fractured, two additional shoulder straps

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The Thoracic Region, Clavicle and Scapula

FRACTURES OF THE RIBS

Etiology. The ribs may be fractured in violent sneezing or coughing, but, more frequently, they are fractured by the transmitted force of a blow on the front of the chest. Much more commonly, the violence is direct, such as a fall against a table or the side of the bathtub, injuries received in automobile accidents, or the impact of a fist. The fracture may be single or multiple and incomplete, complete or comminuted. Slight overriding sometimes accompanies complete fracture, but most often there is no displacement.

Some irritation or injury of the subadjacent pleura always accompanies fracture of the ribs. When the violence is great, the pleura and the lung may be perforated, and paradoxical motion, subcutaneous emphysema, hemothorax, pneumothorax or pulmonary hemorrhage may follow rapidly. Empyema or atelectasis of the lung may occur later. Careful search for such complications must be made when the patient first is seen. When present, hospitalization for observation and treatment is necessary. Internal fixation may be indicated.[1]

Diagnosis. A history of injury and the characteristic aspect of the patient usually suggest the diagnosis at a glance. The patient tends to immobilize the affected rib by speaking deliberately, by hunching himself to the affected side and by compressing the affected area with his hands. Breathing may be labored; it is always shallow. Agonizing spasms of pain accompany coughing or sneezing.

After direct violence, localized swelling and skin injury may indicate the site of fracture; the patient can localize it accurately. On palpation, well-defined areas of tenderness, possibly also irregularity of contour and crepitus, may be found. To differentiate incomplete fracture from simple contusion of the chest wall, compression of the chest with one hand on the back and the other on the sternum may be useful. When a fracture is present, distinct pain should be elicited at the site of fracture. Routine roentgen examination of the chest fails frequently to demonstrate fractures about the anterior and the posterior axillary lines, and oblique views may be necessary. In the presence of a typical clinical picture, a negative roentgenogram must be regarded simply as failure to demonstrate the fracture rather than assurance of its absence.

Roentgen examination is advisable after every chest injury that produces signs of fracture, but it is not necessary for an uncomplicated fracture of

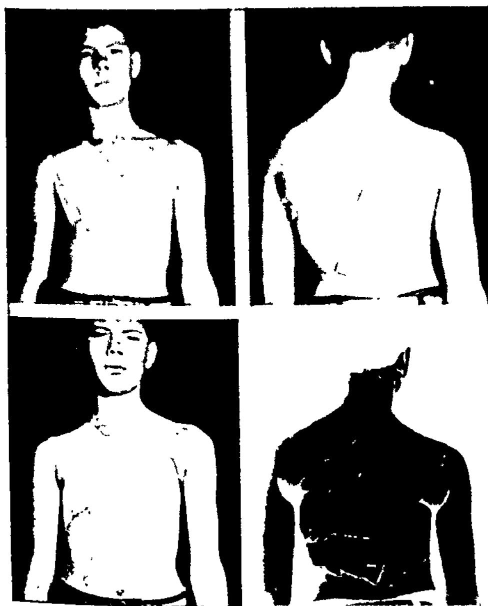


FIG 470. Strapping for pain over the costochondral junctions of the right second and third ribs following an injury The right upper chest is compressed and immobilized by the vertical and the horizontal straps. The same type of strapping is used for fractures of the upper ribs.

that of fracture of a rib close to the sternum or at the costal margin. The patient often experiences a snapping sensation on deep inspiration. A roentgenogram usually is negative, since cartilage is radiolucent.

Treatment. These lesions are treated in the same manner as fractures of the ribs (Fig. 470) Pain may persist for several months, since cartilage heals very slowly. As long as it is present, adhesive strapping or an elastic bandage must be applied about the chest.

Excessively mobile and tender costochondral junctions, producing so-called slipping ribs, usually are traumatic in origin and may be treated by adhesive straps or an elastic bandage

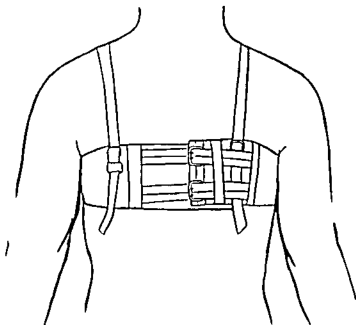


FIG. 469 Elastic girdle applied to chest. (Lee, H. G New England J. Med. 225:409)

are used (Figs. 468, 470). In women with pendulous breasts, it may be impossible to strap the chest over the fracture. In this event, one or two bands of adhesive may encircle the lower chest with moderate tension: this limits the respiratory excursion and gives considerable relief from pain. An elastic adhesive bandage also may be used. Lee[5] has used a chest girdle (Fig 469) that is easily made with good results

The strapping becomes loose in from 2 to 4 days in many patients If it has been tolerated well, it need not be removed, and a tight second layer may be applied directly over it. This may be repeated as often as necessary. Very often, the strapping produces a mild dermatitis with itching or pustules. When this happens, the strapping is removed gently and a nonadhesive elastic bandage from 4 to 6 in. wide is applied instead Alcohol rubs 3 times daily then will be helpful, and in 3 or 4 days the strapping may be reapplied after covering the most irritated areas with gauze. The immobilization of the chest is continued until pain on breathing and local tenderness disappear. This may take from 3 to 8 weeks

Fractures of the ribs in elderly fat women may be one of the most exasperating lesions to treat. Strapping may cause greater discomfort than the fracture because of skin lesions and abdominal distress. Bed rest, sedatives and mild laxatives constitute the mainstay of treatment in these patients.

COSTOCHONDRAL SEPARATION —FRACTURE OF THE COSTAL CARTILAGES

Occasionally, as a result of direct trauma, a fracture may occur at the costochondral junction, this has been called costochondral separation Fractures through the costal cartilage also may occur, they are more apt to involve the lower ribs and the costal margins

Diagnosis. The clinical picture is

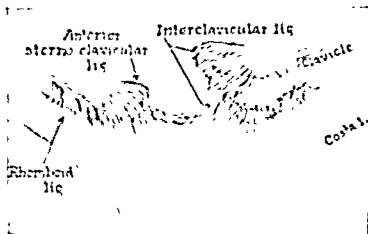


Fig. 471 Sternoclavicular dislocation The common upward and medial displacement of the clavicle is shown.

Fig 472. Roentgenogram of the patient shown at top There is an upward dislocation of the sternal end of the right clavicle. The dressing is applied as shown in the pictures at the bottom.

about the chest. The strapping must be continued until pain and tenderness subside; usually this takes from 4 to 10 weeks because cartilage is slow to heal. Repeated injections of procaine solution may be of value for relief of pain.

In old cases of costal cartilage fracture, suture may be performed under local anesthesia (p. 327).

FRACTURES OF THE STERNUM

Etiology. Fractures of the sternum have been more common in recent years because of the frequency of automobile collisions. In such accidents, the driver is thrown forward against the steering wheel, at high speed, the impact may be so great that, not only is the sternum fractured, but there also may be multiple fractures of the ribs, injury to the thoracic viscera and fractures of the spine, the jaw and the skull. A fracture of the sternum then may be the least of the injuries, and, if it exists without displacement of the fragments, it is easily overlooked. Fractures of the sternum may be caused also by falls on the head or the shoulders. This fracture is rare under 20 years of age, which is the time the upper segments of the bone fuse.

The site of fracture tends to be at or near the junction betwen the manubrium and the body Usually this is the most prominent and narrow part of the bone. Displacement of the upper fragment backward on the lower may take place, and overriding may occur.

Diagnosis. When fracture of the sternum occurs without displacement, the site of the pain and tenderness and the associated severe pain on breathing and coughing suggest the diagnosis immediately. The patient tends to hunch himself, and his breathing is shallow in an effort to ease the pain. Lateral roentgen films usually demonstrate the fracture well, but oblique views may be necessary. When displacement of the fragments occurs, the severity of the pain, associated dyspnea and palpable deformity should make the diagnosis easy.

Treatment. If no displacement is present and there are no complications, a circular strapping of the upper chest with adhesive extending over the shoulders is used. The immobilization should be maintained for 6 weeks or until there is no pain, and the patient should be instructed to avoid heavy lifting for an additional month. Such a patient may be ambulatory. Fractures with displacement may require hospitalization and operation.

Prognosis. The prognosis in uncomplicated cases is good, even though there is residual deformity.

STERNOCLAVICULAR DISLOCATION

Anatomy and Etiology. Dislocation at the sternoclavicular joint is relatively uncommon. The joint lies obliquely, facing upward and outward. A fibrocartilage lies between the clavicle and the sternum, and it is bound strongly to both bones. In addition, dislocation is resisted by the sternoclavicular, the interclavicular and rhomboid ligaments, which tear when dislocation occurs. The rhomboid ligament may remain intact in forward dislocations. A thrust inward on the shoulder may force the inner end of the clavicle upward or forward on the sternum, as well as medially (Fig. 471). The very rare backward dislocation may occur by direct violence.

Diagnosis. The diagnosis of for-

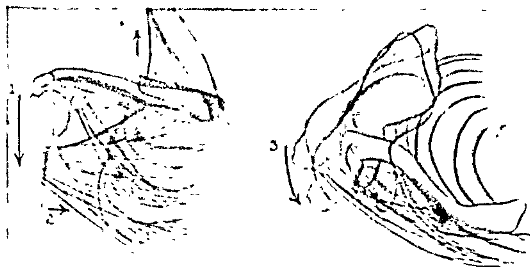


FIG. 473. Fracture of the clavicle as seen from in front and from above. The medial fragment is pulled upward slightly by the sternocleidomastoid muscle. The lateral fragment moves with the shoulder (1) downward, due to the weight of the arm and the shoulder, (2) inward due to the tension of the pectoralis muscles, and (3) forward, due to the added action of the serratus magnus and to the shape of the chest.



FIG. 474. Typical fracture of the clavicle. The inner fragment is elevated, and the outer fragment is displaced downward and inward.

verse or comminuted. When the fracture is complete and the fragments separate, a characteristic displacement follows (Figs. 473, 474). The medial fragment is drawn slightly upward by the sternocleidomastoid muscle. The outer fragment moves downward, inward and forward, due to the weight of the shoulder and the arm and to the tension of the muscles that attach the scapula and the humerus to the chest. These muscles are mainly the pectoralis major and minor, the serratus magnus and the latissimus dorsi.

ward-upward dislocation may be made on inspection and palpation (Fig. 472) because the dislocated end of the clavicle is prominent both to the eye and to the finger Localized tenderness at the sternoclavicular joint may be quite acute. Roentgen examination is advisable for verification and for exclusion of associated fractures. Sternoclavicular dislocation may be partial or complete. The partial type usually can be reduced and maintained in position after reduction, while the complete type may be irreducible or impossible to maintain in the reduced position.

Treatment. Reduction of the forward-upward displacement is not difficult unless an infolding of the torn ligaments occurs Anesthesia may not be necessary, but, when it is, infiltration of 10 to 15 cc. of 2 per cent procaine hydrochloride solution about the joint will give complete freedom from pain. The maneuvers are the same as for reduction of a fractured clavicle (p. 658). The patient lies on a table with a sandbag between the scapulae While an assistant holds the opposite shoulder to the table, with one hand the surgeon presses the shoulder of the injured side toward the table and cephalad, and with the other hand forces the inner end of the clavicle downward and caudad. Maintenance of reduction always has been difficult. A felt pad about 3 in. square and 1 in. thick can be made to press on the dislocated end of the clavicle by 2- or 3-in. adhesive cross straps applied with considerable tension after the patient exhales forcibly (Fig. 472). When any tendency to recur is present, a clavicular T-split or a posterior figure-of-eight bandage also is applied to hold the shoulders backward and outward; otherwise, a sling for the affected arm is enough. Very gentle active use of both arms may be encouraged from the beginning. The adhesive strapping and the splint must be inspected every second day for 2 or 3 weeks. From 5 to 6 weeks' immobilization is advisable; a shorter period may cause recurrence of the dislocation. Usually, however, good function may be expected, even with a persistent partial dislocation.

If the dislocation is irreducible or if it is impossible to maintain reduction, operative correction should be considered.

Prognosis. In partial dislocation, no permanent effect other than slight thickening about the joint may be expected. After complete dislocation, failure to maintain a good reduction may require operation, the result of which usually is good.

FRACTURES OF THE CLAVICLE

Anatomy and Etiology. The clavicle functions as a rigid prop or pivot for the shoulder girdle, maintaining the shoulder joint at a fixed distance from the sternum. It is the only bony connection between the upper extremity and the trunk.

The clavicle is one of the bones most often fractured. In every fall on the outstretched hand or arm and in every fall on the point of the shoulder, the shoulder is thrust toward the chest The clavicle receives this thrust and usually breaks at its weakest portion, the junction of its two curves, between the middle and the outer thirds. Occasionally, this fracture is found in a newborn infant. Fractures also may occur by direct violence when the bone is struck directly on its anterior or superior surface.

Displacements. The fracture line usually is oblique, but it may be trans-



FIG. 477. Anterior and posterior views of figure-of-eight dressing. Double thickness felt is used for the axillary pads the 2 loops are prevented from slipping by the strip of bandage which is pinned on each side. Three thicknesses of felt are applied over the back The axillary pads are long enough to meet the pad in back

or muslin bandage 2, 3 or 4 in. wide, depending on the size of the patient, 3 felt or cotton pads 1 in. thick and 6 x 8 in. wide for adults (smaller for children), and 3 safety pins. Felt pads should be wrapped in gauze.

The patient elevates the uninjured arm, and an assistant elevates the other. A strip of bandage is laid across the chest in front of the shoulders, and the pads are placed just in front of and below each shoulder joint and over the scapulae. The posterior figure-of-eight then is applied with moderate tension and pinned in the back The ends of the bandage previously laid across the chest are pulled together, and each side is pinned to the anterior turns of the figure-of-eight bandage (Fig 477). A similar dressing may be made with a plaster bandage. Felt pads are placed in each axilla and on the back, and the wet plaster bandage is used to make a posterior figure-of-eight. No anterior band is used. The plaster is molded beneath the axilla into a narrow thick band, so that the arm may be brought to the side without too much discomfort (Fig. 478).

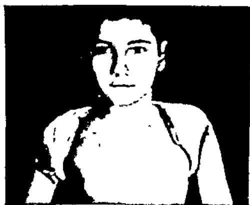


FIG. 478 Posterior figure-of-eight plaster dressing for fracture of the clavicle. The plaster was applied after the anterior aspect of the shoulder, the axilla and the back had been protected by felt.

In the first few days, the patient may complain of axillary discomfort, and so instructions are given to rest the arm in the horizontal position if necessary. We encourage the use of both arms freely within the limit of pain. The bandage dressing usually needs to be adjusted and tightened every 3 or 4 days. The skin of the axillas and over the shoulder should be watched carefully, and at every opportunity it should be washed thor-





Fig. 475 (*Left*). Fracture of the left clavicle. The characteristic deformity is visible.

Fig. 476 (*Right*). Fracture of the left clavicle with slight angulation and beginning callus formation. This patient sought medical aid because of "a lump near the shoulder."

In children, the fracture frequently is of the greenstick type (Fig. 476), with a relatively slight displacement consisting mainly of increased angulation

Diagnosis. When the fracture is complete, the patient may have a characteristic posture; the head is carried forward and to the injured side to relieve the tension on the inner fragment. The arm on the affected side is cradled in the other hand to relieve the tension on the outer fragment caused by the weight of the arm Inspection may reveal a typical deformity (Fig. 475) Palpation and comparison with the unaffected side disclose thickening, angulation or sharp edges associated with localized acute tenderness and crepitus. Motion of the arm causes pain at the fracture site. Practically always, an accurate diagnosis can be made in a moment or two, except when there is unusual swelling

When the fracture is incomplete, the diagnosis may be made by the history and the slight swelling and the localized acute tenderness, which are accompanied by some pain on motion and limitation of elevation of the arm. The actual disability of the arm on the affected side may be very slight. Not infrequently, a child is brought in by a parent because of a "lump near the shoulder" which proves to be a fracture of the clavicle of 1 or 2 weeks' duration with excessive callus formation resulting from lack of immobilization (Fig. 476).

Roentgen examination serves to show the exact type of fracture and the degree of displacement in complete fractures and to verify the diagnosis when the fracture is incomplete. In the rare fractures very close to either the sternal or the acromial ends, roentgenograms may be necessary to differentiate these from sternoclavicular or acromioclavicular separations.

Treatment of Incomplete and Greenstick Fractures. Many methods for treating fractures of the clavicle have been described. Their value varies according to the type of fracture and the age and the sex of the patient. Practically always, these fractures unite with good subsequent function, so that the problem is one of selecting the form of treatment best suited to the particular case.

Incomplete and greenstick fractures require very little treatment. A posterior figure-of-eight dressing provides adequate immobilization. The materials required are 5 yards of flannel

Infiltration of 10 to 15 cc. of 2 per cent procaine hydrochloride solution into the hematoma about the fracture produces excellent anesthesia in 10 minutes. Frequently, no anesthetic is necessary if the maneuvers are carried out gently. The displacement of the medial fragment rarely is marked, and in any event it can be controlled but poorly. The displacement of outer fragments can be corrected easily by bringing the shoulder up, out and back. One of two methods may be used. In the first (Fig. 179), the patient sits on a stool. The assistant stands behind him, puts his knee between the scapulae and draws both shoulders upward and backward forcibly. The surgeon stands facing the patient and manipulates the fragments into alignment, the assistant maintaining the traction until the splint has been applied.

A wood or an aluminum clavicular *T-splint* may be used (Fig. 182). The cross piece must be the full width of the shoulders, and the vertical piece must be long enough to reach from the base of the neck to the sacrum. The anterior surfaces of both are covered with felt, and the felt axillary pads must be at least 1 in. thick. The vertical piece is bent to conform to the shape of the back in the upright position, and the low webbing strap is fastened about the trunk below the iliac crests. While both shoulders are held upward and backward, they are strapped to the cross piece. An anterior transverse strap holds the 2 shoulder straps in position. These splints must be inspected frequently, and the skin, especially of the axilla, must be watched carefully.

A satisfactory dressing for fractures that are stable after reduction is a snugly fitted posterior figure-of-eight

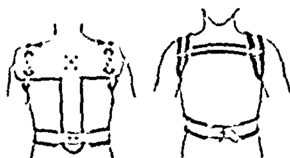


Fig. 182. T splint for fracture of the clavicle.

plaster dressing (Fig. 178). The patient is instructed to relieve axillary discomfort by elevating the arms and to continue active use of both arms within pain limits. There often is considerable discomfort during the first 18 hours after reduction; this may be relieved by morphine tablets by mouth. After the first week, there is little or no discomfort and the patient has almost normal use of the arms. After 4 weeks, union usually is solid enough to warrant active use without support. The appearance of callus as a definite fusiform thickening and the absence of tenderness are the usual indications for discarding the splint.

The crutch type of splint sometimes will be useful when a simpler dressing fails (Fig. 483). This holds the shoulder up and brings the outer fragment into the line of the inner fragment, at the same time permitting function of the arm. This dressing must be inspected and adjusted at frequent intervals.

For less stable fractures, Quigley[7] suggests reduction and fixation in the semirecumbent position with immobilization of both the sternoclavicular and the acromioclavicular joints. A table is placed with one end against a wall, and the patient sits with his back to the wall and with a piece of plank 1.9 cm. thick beneath the buttocks. A broomstick is laid between



FIG. 479 Reduction of a fracture of the clavicle with the patient sitting on a stool. The assistant stands behind the patient, puts his knee between the scapulae and draws both shoulders upward and backward forcibly. The surgeon stands facing the patient and manipulates the fragments into alignment. Traction is maintained by the assistant until the dressing has been applied





FIGS 480 and 481. Reduction and application of plaster in semirecumbent position. (Quigley, T. B New England J Med 243:286)

oughly, rubbed with alcohol and powdered. Cotton may be inserted under the felt pads to prevent rubbing. Callus forms rapidly and becomes palpable in 2 to 3 weeks, but the dressing is maintained until union is solid, usually 4 weeks The plaster dressing seldom requires replacement

Reduction of Complete Fractures with Displacement. In reducing fractures of the clavicle, difficulty seldom is encountered in aligning the fragments Maintenance of reduction is the problem, and, of the 200 and more methods devised so far, none is entirely satisfactory.

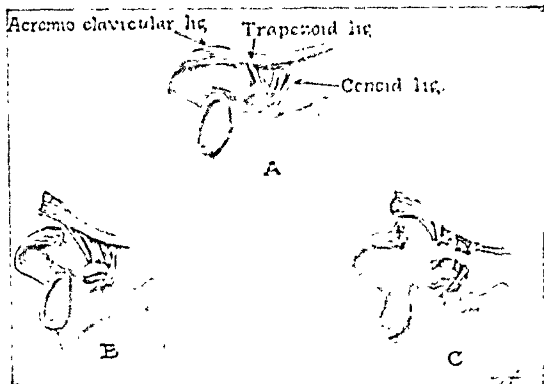


Fig. 484. Acromioclavicular dislocation (A) Normal acromioclavicular attachments (B) Incomplete type of dislocation in which the conoid and the trapezoid ligaments suffer little injury (C) Complete dislocation with all ligaments torn.

of the clavicle becoming much more prominent; it is movable also on the acromion, especially when the dislocation is complete (Fig. 485). Palpation reveals the deformity, even in the presence of considerable swelling. Determining the exact point of wincing tenderness and comparison with the opposite side help to differentiate this lesion from fracture of the outer end of the clavicle. Since a fracture may complicate this dislocation, roentgen examination always is in order.

The subluxations offer some difficulty in diagnosis, and even the roentgenologist may have his troubles. Examination of both shoulders by films and determination of the comparative mobility of both acromioclavicular joints under the fluoroscope are of value in doubtful cases.

Treatment. The downward pull of the weight of the arm and the shoulder tends to maintain the displacement. Reduction can be effected by outward and backward traction on the shoulder, accompanied by downward pressure on the prominent end of the clavicle, but the displacement tends to recur almost instantaneously. Reduction must be maintained while the retentive dressing is applied, and the adhesive straps of the dressing must be made tight every 2 or 3 days.



Fig. 485. Complete dislocation of the acromioclavicular joint.

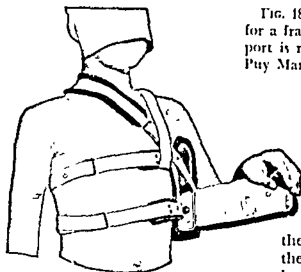


FIG. 483. Crutch type of splint (Böhler) for a fractured clavicle. The forearm support is removed after 1 or 2 weeks (DePuy Manufacturing Company)

the wall and the edges of the plank (see Fig. 480) at an angle of 45° from the horizontal. A thick felt pad is placed across the back from one posterior axillary fold to the other, and the patient is made to lie with his vertebral column against the broomstick and with his arms hanging on either side of the table The fracture site then is infiltrated with procaine solution and manipulated. A plaster dressing is applied after placing additional felt in both axillae and sheet wadding round the chest as shown in Figure 481. If roentgen examination shows satisfactory position, the dressing is allowed to remain for at least 4 weeks.

For badly displaced, unstable and complicated fractures, Kirschner-wire intramedullary fixation[2,6] has come more and more into use. It requires brief hospitalization.

Prognosis. When the fracture is incomplete or when a complete fracture can be reduced and maintained in good position, the functional result will be excellent. There will be visible thickening at the fracture site, which will decrease after a lapse of time. When a satisfactory position of the fragments cannot be maintained, the functional result usually is good, but the visible deformity may be considerable. (In very rare instances, nonunion with persistent pain and symptoms of pressure on the brachial plexus may require operation.)

ACROMIOCLAVICULAR DISLOCATION

Etiology. Acromioclavicular dislocation occurs comparatively often. It is a very common injury of contact sports, especially football A blow on top of the shoulder that forces the acromion downward and inward may shear through the acromioclavicular ligaments and cause subluxation. Greater violence results in torn coracoclavicular (conoid and trapezoid) ligaments and complete dislocation (Fig. 484). Horn[4] at operation on 9 cases found, in addition, substantial stripping of the deltoid and the trapezius attachments of the clavicle, with disruption of the joint capsule and partial extrusion of the meniscus in some cases.

Diagnosis. Immediately after the injury, the patient complains of inability to use the arm and the shoulder. Later, there are swelling and pain at the tip of the shoulder, increased by elevation of the arm. The displacement is characteristic, the outer end

Dislocations which are irreducible because of *infolded ligaments*, failure to maintain reduction and long standing dislocations of 1 to 2 months or more may necessitate operative correction. Operation should be advocated in severe injuries in those doing heavy manual work.[4]

Prognosis. Incomplete dislocations heal rapidly and leave no effects. Complete dislocations may require open operation, the result of which usually is good. The chief difficulty in this injury is that the patient begins to use the arm before healing is complete. This is seen most often in football where the players are reinjured each Saturday. A partial dislocation may become complete if adequate healing is not permitted to occur.

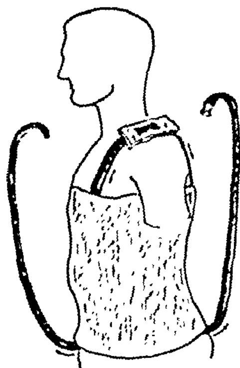


Fig. 487 Wolin's method of conservative treatment of acromioclavicular dislocation. A simple torso cast is applied. This is used to provide downward pressure over the acromioclavicular joint by means of a felt pad and webbing strap. (Wolin, Irving. J. Bone & Joint Surg. 26:589)



Fig. 488 Front and back views of Wolin's dressing for acromioclavicular dislocation. (Wolin, Irvin. J. Bone & Joint Surg. 26: 589)



FIG 486 Dressing for acromioclavicular subluxation

For a temporary dressing a thick (2-in) pad is tied in the axilla, and a felt pad about 3 in. square and 1 in. thick is placed over the acromial end of the clavicle, a similar pad is held against the undersurface of the flexed forearm just below the point of the elbow A 2-in. adhesive strap is started on the mid-line of the back below the scapula and carried upward and outward over the clavicular felt pad, then down the anterior surface of the arm, over the lower felt pad and up the opposite surface of the arm until it crosses the clavicular felt pad again and continues across the front of the chest to a little beyond the mid-line. A 3-in. muslin bandage is used to make a wrist sling, the forearm remaining at a right angle to the arm (Fig. 486). A snug muslin-bandage swathe then is tied about the chest and the arm The axillary pad acts as a fulcrum, and the shoulder moves outward, lessening the tendency to recurrence of the displacement. For definitive immobilization the method of Wolin or Gunther and Snell may be used.

Good union of the ligaments occurs in 4 to 6 weeks in subluxations and in about 8 weeks in complete dislocations. Every 3 to 5 days the swathe must be removed and the adhesive loop tightened by placing a new loop on top of the old Otherwise, the dressing becomes loose, and the displacement recurs. A piece of the adhesive in front of and behind the arm may be removed and replaced by rubber tubing, thus providing constant elastic pressure.

Wolin has maintained reduction by a strap fastened to a cast about the chest and the abdomen (Figs 487 and 488) By this method of treatment, full use of the arm is permitted. Gunther and Snell[3] have maintained reduction by a strap secured to a plaster girdle about the chest (Fig 489)

sive, the accompanying pain and swelling are considerable, and bed rest, application of ice bags and sedatives may be needed for from 24 to 48 hours. As soon as the patient is up, an axillary pad, sling and swathe dressing is applied (Fig. 502). At the end of 1 week, baking, massage and gentle exercises are begun and continued until the shoulder is free of pain and has a full range of motion. After the second or the third week, a triangular sling may be adequate and daily active use permitted. Full active use is resumed at the end of 4 or 5 weeks.

Fracture of the Acromion

Diagnosis. This fracture results from a blow on top of the shoulder. The tension of the deltoid and the



FIG. 490. Fractures of the scapula (a) body, (b) acromion, (c) neck, (d) glenoid and (e) coracoid.





FIG. 491. (*Left*) Examination for fracture of the body of the scapula. The acromion is pressed down with one hand, and the other hand grasps and moves the angle of the scapula to determine mobility and crepitus. (*Right*) Adhesive strapping for a fracture of the body of the scapula. The straps begin in the anterior axillary line on the injured side. They are pulled tight over the scapula and pass over the opposite shoulder to beyond the clavicle. A sling is to be added.

This patient had an injury to the rhomboideus muscle at its insertion into the vertebral border of the scapula. The arrow points to the tender area. The muscle is relaxed when the scapula is taken toward the spine.

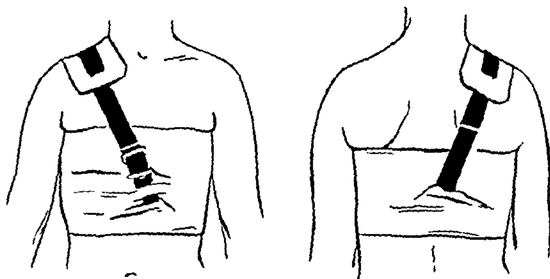


FIG. 489. Over stockinet, a plaster girdle is applied about the chest from the nipples to the lower rib margin. Using a heavy wire, a belt buckle is attached to the anterior mid-line of the plaster, and a webbing belt 1½ in. wide and 3 ft long is attached to the posterior mid-line, and both are angled toward the injured side After the plaster sets, a heavy felt pad is placed over the outer end of the clavicle, and the belt is drawn tight over it. Roentgen films then are made. A sling is worn for the first week. The belt is tightened when necessary The plaster is kept on for from 4 to 6 weeks. (Gunther, W. A., and Snell, W. E.: U. S. Nav. M. Bull. 47:116)

FRACTURES OF THE SCAPULA

Fractures of the scapula may be classified according to the part of the bone involved: body, acromion, neck, glenoid and coracoid (Fig. 490).

FRACTURE OF THE BODY OF THE SCAPULA

This fracture, which occurs only rarely, is caused as a rule by direct violence. The body is a flat plate of bone covered on both sides by thick muscular masses; hence, separation of the fragments seldom is of any importance. Body fractures may be single or comminuted.

Diagnosis. A history of direct trauma followed by pain over the bone on moving the shoulder, localized tenderness and swelling usually indicate a fracture. If the acromion is pressed down with one hand and the angle is pushed medially by the other, localized pain, crepitus and mobility of fragments may be disclosed (Fig. 491, *left*).

Treatment. When the fracture is a simple fissure, an adhesive strapping (Fig 491, *right*) and a triangular sling immobilize it adequately. After 3 or 4 days, mild heat and gentle massage are started In 2 or 3 weeks, healing is sufficient to permit full use.

When the fractures are more exten-

with the mechanics of the shoulder joint, ambulatory treatment is satisfactory.

Treatment. During the acute post-traumatic phase, bed rest, ice bags locally and sedatives are indicated. After 2 or 3 days, an adhesive loop dressing similar to that described for acromioclavicular separation (p. 662) is applied. This forces the head of the humerus and the glenoid upward. A wrist sling and swathe complete the dressing. Physiotherapy is instituted as in fractures of the acromion (p. 665). When very marked displacement of the head threatens to interfere seriously with shoulder function, reduction may be effected perhaps by traction on the abducted arm, accompanied by upward pressure on the distal fragment of the scapula in the axilla. If the malposition is persistent, consultation with a surgeon is advisable.

Fracture Through the Glenoid

Occasionally, this accompanies dislocation at the shoulder, and, unless very great comminution or displacement is present, it requires no special treatment beyond that instituted for the dislocation.

Fracture of the Coracoid

This fracture is very rare. A pressure pad is strapped over the coracoid, and an axillary pad, sling and swathe dressing is applied. Immobilization is continued for from 3 to 5 weeks.

Prognosis of Fractures of the Scapula

Fractures of the body of the scapula rarely leave any permanent disability. Fractures of the acromion, the neck, the glenoid and the coracoid practically always unite and cause little trouble. Rare and atypical cases of body or glenoid fracture may require operation.

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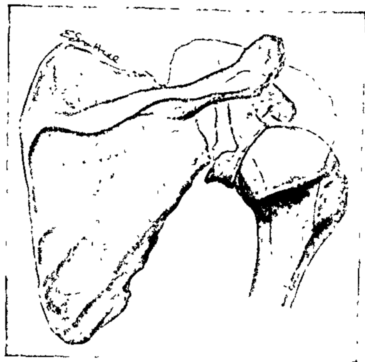


Fig. 492. Fracture of the neck of the scapula. The articular fragment is pulled down by the weight of the arm.

weight of the arm then tend to carry the outer portion of the acromion downward. The diagnosis may be made from the history, local swelling, tenderness and irregularity of contour.

Treatment. If pain is severe, bed rest is helpful with the arm abducted for 2 or 3 days. In the ambulatory patient, an adhesive loop dressing such as that used for acromioclavicular separation (Fig. 486) is applied. It presses the flexed forearm upward, makes counterpressure on top of the shoulder medial to the fracture site, and tends to bring the other fragment into line. A wrist sling and swathe complete the dressing. The immobilization is continued for from 4 to 6 weeks. Active exercise of the hand and baking and massage of the arm and the shoulder are started after 3 or 4 days. After the dressings are discarded, exercises are begun, and baking and massage are continued until the patient can move through the full range of motion without pain, usually about 7 or 8 weeks from the time of injury.

When there has been no displacement of the outer fragment, a sling and swathe dressing is adequate, and shoulder motion may be started after 2 or 3 weeks.

Fracture of the Neck of the Scapula

Fracture of the scapular neck may follow falls on the hand or the arm. When the fracture is complete, the weight of the arm pulls the glenoid downward, and the space between the acromion and the head of the humerus becomes wider (Fig. 492).

Diagnosis. The diagnosis may be suspected after a violent injury to the shoulder, when pain and swelling without definite fracture or dislocation of the humerus are marked. Widening of the acromiohumeral space and palpable irregularity of the axillary border of the scapula may be present. When the displacement is not enough to interfere materially

antecedent violence or the absence of violence.

2. The time of onset of symptoms and their progress.

3. The distribution of pain and its persistence or degree of intermission, its relation to use and movement, its character, its occurrence during sleep and the amount of sedatives required for its relief.

4. The character of disability or its absence.

5. The occurrence of paresthesias.

6. The occurrence of vascular disturbances.

Traumatic lesions about the shoulder include fractures, dislocations, rupture of muscles and tendons, strains, sprains, traumatic bursitis and, occasionally, the scalenus syndrome.

The degenerative lesions, such as calcareus tendinitis and villi and bands in the subacromial bursa, may or may not be associated with a history of injury. Occasionally, symptoms are attributed to a trifling injury, usually insufficient to account for them. The cervical rib syndrome and the scalenus syndrome may or may not be preceded by an injury.

Examination

Methodical examination is essential for accurate diagnosis. It should be made with the patient stripped to the waist, sitting on a stool and squarely facing a good light. Notes should be made as the examination proceeds.

In dislocation of the humerus, fracture of the clavicle or injury to the neck, inspection may disclose a characteristic posture. The deformity of sternoclavicular dislocation, acromioclavicular dislocation, fracture of the clavicle and dislocation or fracture of the humerus may be striking, but even when less marked will be innative.

Swelling, discoloration, muscle spasm, muscle atrophy and signs of circulatory disturbances should be noted.

On palpating the shoulder, the examiner must avoid causing any unnecessary pain. Starting at the sternoclavicular joint, the outlines of the clavicles, the acromioclavicular joints, the heads of the humeri and the scapulae are compared. Deformity and tenderness can be identified. The muscles of the neck, the shoulders and the scapular regions next are explored by firm, deep pressure for tenderness and spasm.

The degree of disability and the range of motion of the shoulder must be determined, provided there are no fresh fractures that can be displaced. The ability to elevate the arm actively and the range of passive motion are of particular interest. Limitation of internal and external rotation is to be noted, as are the points at which pain is produced by motion. Localized tenderness and pain on motion at any point usually indicate an underlying lesion, especially when the spontaneous pain of which the patient complains is in the same area.

The examination is not complete until circulatory, sensory and motor changes have been determined.

Thus, more than one injury may be found, and muscular, joint and bursal injuries will receive their share of attention. In the presence of obvious fractures and dislocations, the soft-tissue injuries that often lead to prolonged disability are apt to be overlooked.

DISLOCATION OF THE HEAD OF THE HUMERUS

The head of the humerus is much larger than the glenoid, and the capsular ligament is loose about its entire

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The Upper Extremity

MECHANISM OF THE SHOULDER

The upper extremity is attached to the trunk by a mechanism of great flexibility. There are five points at which motion occurs when the arm is elevated above the head:

1. The scapulohumeral joint is located between the head of the humerus and the glenoid fossa, and is surrounded by a loose capsular ligament

2. The subacromial bursa lies below the acromion process and the deltoid muscle; it is above the greater tuberosity and the short rotators. The greater tuberosity slides under the acromion when the arm is elevated fully. (See subacromial bursa, p. 458).

3 The scapulothoracic plane of motion is situated between the posterior portion of the serratus magnus and the chest wall. The scapula rotates when the arm is elevated, the glenoid moving upward. The scapula also can move forward and backward on the chest wall.

4. The acromioclavicular joint also is a point of motion, the acromial end of the clavicle moves upward and rotates when the arm is elevated.

5. The sternoclavicular joint acts as a stabilizing pivot for the shoulder girdle. The clavicle rotates somewhat on its long axis, and the angle between its long axis and the sternum increases when the arm is elevated.

Normal arm elevation is a synchronization of these motions. Essentially, the humerus rotates upward on the scapula, and the scapula rotates on the chest wall so that the glenoid faces upward instead of outward. The humerus rotates on the scapula at the shoulder joint proper and at the subacromial bursa, where the greater tuberosity must slide beneath the acromion for full elevation. The scapula rotates on the chest wall and on the outer end of the clavicle. The inner end of the clavicle rotates on the sternum. Disturbances of shoulder function may occur at any of these points and may originate from fractures and dislocations, lesions of the shoulder joint, the subacromial bursa, the acromioclavicular articulation and the sternoclavicular articulation and lesions of the muscles, the tendons and the nerves concerned in shoulder motion. Lesions of the cervical spine also may cause pain of mechanical origin about the shoulder. Lesions of thoracic and abdominal viscera may cause pain about the shoulder, but these lesions will not be considered here, since they are rarely confused with those arising in the shoulder area.

DIAGNOSIS OF LESIONS ABOUT THE SHOULDER

History

A detailed history is valuable, and the main points of interest are:

1. The nature and the extent of





FIG. 191. Subcoracoid dislocation of the left humerus. (*Left*) Roentgen appearance and visible deformity. (*Below*) Reduction by Kocher's method.

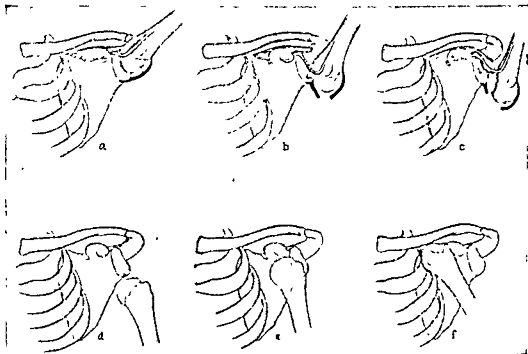


FIG. 493 Mechanism and complications of dislocation of the humerus (a) The acromion impinges on the shaft of the humerus at maximum abduction. (b) As further abduction is forced, the acromion acts as a fulcrum for the lever arm of the humerus The capsule tears at the point of maximum strain, and the head of the humerus goes downward. The supraspinatus tendon may tear. (c) The greater tuberosity may be torn off and the biceps tendon pulled away from its groove. The inferior margin of the glenoid may be fractured When the arm falls to the side, the head lies in the subglenoid position (d), the subcoracoid position (e) or the subclavicular position (f).

circumference The acromion and the coraco-acromial ligament prevent upward displacement of the head. Dislocation takes place through the lower half of the capsule and is resisted by the muscular attachments about the head. When these dislocations occur, extensive muscle and tendon injury may accompany them.

TYPES

There are several varieties of dislocations. Anterior or subcoracoid dislocation is the common form The head bursts through the antero-inferior portion of the capsule and comes to rest beneath the coracoid process. Rarely, when the violence is very great, the head is carried farther inward to rest beneath the clavicle, a subclavicular dislocation thus being produced. Second in frequency is the downward, or subglenoid type of dislocation in which the head lies directly beneath the glenoid (Fig. 493) Subspinous, or backward, dislocation is one of the rare forms.

MECHANISM OF DISLOCATION

When the arm is so rotated and elevated that some part of the neck of the humerus lies against the acromion, the normal limit of motion is reached When the humerus is forced beyond



Fig. 495. (*Left*) Subglenoid dislocation complicated by fracture of the tuberosities. (*Right*) After reduction the tuberosities resumed their normal position. If the tuberosities had retracted under the acromion (Fig. 517) and good position could not have been obtained, operation would have been indicated.



Fig. 496. Reduction of a dislocation of the head of the humerus by Cooper's method.

this limit, the acromion becomes the fulcrum on which the head is levered away from the glenoid and tears through the inferior portion of the capsule. There may be a compression fracture of the head. As the head leaves the glenoid fossa, the short rotator muscles may be torn,[9] the greater tuberosity may be fractured, or a portion of the glenoid may be broken off. The head assumes its final position when the arm falls to the side by its own weight.

Diagnosis

Frequently, the diagnosis can be made as the patient walks to the room. The elbow is supported well away from the body. With the patient undressed, visual and tactile comparison of the shoulders demonstrate the flattening of the deltoid and the absence of the head of the humerus from its position beneath the acromion (Fig. 494). The head may be palpable in the axilla beneath the glenoid, or it may be both palpable and visible in its position beneath the coracoid. Measurement with the arm at the side demonstrates increase in the length from the acromion to the point of the elbow. If the hand of the injured side is laid on the opposite shoulder, the elbow cannot be brought against the chest wall.

After making the diagnosis, motor and sensory changes in the extremity indicative of injury to the brachial plexus must be sought and their presence or absence noted. While roentgen examination is not necessary for diagnosis, nevertheless it is advisable. Frequently, fractures of the greater tuberosity or the neck of the humerus or of the lower lip of the glenoid fossa complicate the dislocation and may pass unrecognized until adequate films are made (Fig. 495).

Treatment

Reduction should be carried out without delay. After from 2 to 3 weeks, closed reduction may be impossible. As a rule, general anesthesia is preferred. Occasionally, if the patient is seen within an hour or so, if he is not too muscular and if he is willing to bear a little pain, reduction may be effected under local anesthesia. A skin wheal is made about 1 in. below and anterior to the acromion. A long needle is inserted into the joint space, and 20 cc. of 1 per cent procaine hydrochloride solution is injected. An additional 10 to 15 cc. of solution is injected about the dislocated head. After 10 minutes, manipulation may be started.

Kocher's Method

In uncomplicated anterior dislocations, this method has given satisfactory results consistently. It consists of 3 stages as follows:

Stage 1 (Fig 494). The surgeon grasps the patient's wrist in one hand, holds the elbow with the other and flexes the forearm to a right angle. With the elbow held firmly against the chest, the wrist is brought slowly outward until the arm is in full external rotation (70°-90°).

Stage 2. While external rotation and adduction are maintained, traction is made on the elbow as it is brought forward and inward very slowly toward the mid-line of the body. Very often, reduction occurs during this maneuver.

Stage 3. If reduction has not occurred, the wrist is brought inward until the hand rests on the opposite shoulder.

Cooper's Method

For reduction of a subglenoid dislocation (Fig 495), the hippocrati



FIG. 498. Backward dislocation of the left shoulder (*left*) shows the flattening of the deltoid bulge, (*center*) the increased anteroposterior dimension of the shoulder and (*right*) reduction by traction and pressure

ing is changed, helps to prevent troublesome stiffness. After 2 weeks, a simple sling is applied, and active use of the arm is begun. Raising the arm beyond 60° is not permitted for another 2 weeks. Then full use may be resumed gradually, the patient being cautioned about vertical elevation of the arm.

COMPLICATIONS

Fracture of the inferior lip of the glenoid fossa often is present but requires no special treatment Fracture of the greater tuberosity may be present. If the fragments are in good position, no special treatment is indicated, however, when the tuberosity has been retracted inward by the supraspinatus muscle, measures for approximation of the tuberosity to its bed must be taken. These are described under fractures of the greater tuberosity (pp. 687-689). The subacromial bursa suffers extensive lacerations and contusions, and this accounts for the prolonged disability that sometimes follows dislocation. When any evidence of injury to the brachial plexus or the circumflex nerve (deltoid paralysis) is present, immobilization in the abducted, slightly externally rotated position is indicated until symptoms subside, which is from 3 to 10 weeks.

OLD DISLOCATION OF THE HEAD OF THE HUMERUS

Occasionally, patients complain of pain and disability at the shoulder of many months' or years' duration. Figure 499 shows the range of motion in such a case. The physical signs indicate a dislocation, and roentgen films verify the diagnosis.

Treatment. If the disability in an elderly patient is not too great, no operation is indicated; otherwise, it is the treatment of choice.

FRACTURE DISLOCATION OF THE HEAD OF THE HUMERUS

Fracture dislocation of the head of the humerus (Fig. 500, *left*) is an uncommon lesion. The dislocated head

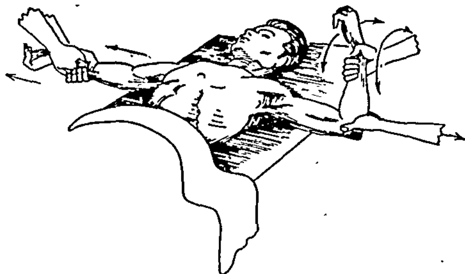


FIG. 497. Position of patient and direction of forces exerted for the reduction of dislocated shoulder. (Bush, Leonard F · Am J. Surg. 67: 521)

Cooper's, method is satisfactory (Fig 496). This makes use of manual traction and the leverage of the humerus over a heel in the axilla. The patient lies flat on his back on a table, the surgeon grasps the wrist on the affected side and places his stockinged foot (the right foot for the right shoulder) in the axilla so that it lies between the chest wall and the upper end of the humerus While traction is made on the arm, it is brought close to the side so that the heel acts as a fulcrum, forcing the head of the humerus outward. If the head does not slip in, gentle outward rotation of the arm may help

Bush[3] suggests a similar method After administering morphine sulfate, gr. 1/4, the patient is placed supine. An assistant applies firm traction on the opposite arm, or the patient may be fastened to the table with a sheet round the thorax. Gentle, constant and increasing traction is applied on the arm involved, with the elbow flexed at a right angle, the forearm being held in a vertical position. The patient is reassured and asked to breathe deeply and relax the shoulder muscles. While constant traction is maintained, the flexed arm is rotated gently toward the head, and reduction occurs with ease. Anesthesia may be used (Fig. 497).

Backward dislocation may be reduced by pressure from behind with gentle traction and rotation of the arm (Fig 498).

After reduction, the arm is held at the side and dressed so that the head of the humerus is forced upward against the acromion. An adhesive loop dressing, such as described for acromioclavicular separation, is applied (Fig 486). A thin axillary pad with a sling and swathe complete the dressing.

The arm must be kept snugly at the side for 2 weeks During this time, the hand should be exercised and the forearm and the arm massaged. Gentle motion of the shoulder, carried out at 3- or 4-day intervals when the dress-

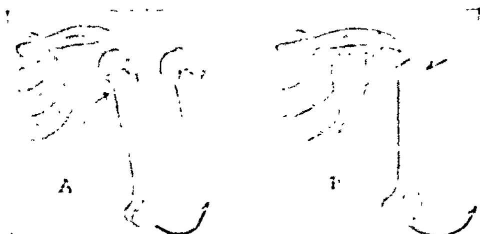


Fig. 501. Epiphyseal separation of the head of the humerus: its displacement and reduction. (A1) The shaft lies in front of the head. (A2) the shaft lies behind the head. In these types the neck must be pressed outward while traction and abduction are made on the arm. (B) In this type, the neck is pressed inward while traction and abduction are made on the arm.

and lies on the opposite shoulder, differentiating this lesion from simple dislocation.

Treatment. For preliminary treatment, an axillary pad, sling and swathe dressing is applied, and a sedative is administered. Immediate roentgen examination and very early reduction are extremely valuable. Reduction of the dislocated head is effected under either local anesthesia, 20 cc. of 2 per cent procaine hydrochloride into the fracture site, or general anesthesia by strong, steady mechanical traction on the arm and manipulation of the dislocated head. Closed reduction may fail; if so, open reduction is indicated. Excision of the loose unimpacted head has been advocated.[21]

EPIPHYSEAL SEPARATION OF THE UPPER END OF THE HUMERUS

Epiphyseal Development. The epiphysis for the head of the humerus *may* show a center of ossification at birth. It is present almost always at the age of 3 months. The epiphysis unites to the shaft at from 20 to 23 years of age. In the first 7 years the epiphysiodiaphyseal junction is more or less flat (Fig. 500, *inset*). Later it changes shape, the upper end of the diaphysis becomes conical and fits into a corresponding concavity of the epiphysis so that displacements have little tendency to recur after reduction.

Epiphyseal separation may occur at any time before the epiphysis unites to the shaft, but it is most common between 12 and 19 years of age.

Displacement. Displacement may be slight or absent when the violence has not been great. When complete separation of the epiphysis occurs, it is often in the abduction external-rotation position of the head. The upper end of the diaphysis often moves upward and forward, and may be displaced medially or laterally (Fig. 501). Impaction may occur. A portion of the diaphysis may be broken off with the epiphysis.

Diagnosis. In adolescence, a history



FIG. 499. (*Left*) An old subcoracoid dislocation of the humerus (*Right*) Showing good range of motion obtained by exercise; no operation was performed

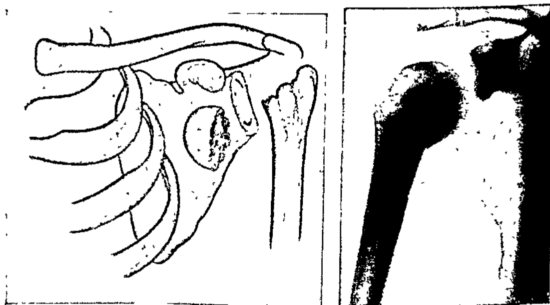


FIG. 500 (*Left*) Fracture dislocation of the head of the humerus. (*Right*) Epiphyseal separation at the upper end of the humerus in a 14-year-old boy (Eliason, E. L., and Ferguson, L Kraeer Surg Gynec & Obst. 58.85)

is broken off and lies outside the capsule of the shoulder joint in the subglenoid or the subcoracoid position, while the end of the shaft may go back into the joint space. This injury requires hospitalization.

Diagnosis. The clinical picture is similar to that in displaced fracture of the surgical neck of the humerus, but the head of the humerus is not palpable beneath the acromion, and often it can be felt readily beneath or in front of the glenoid The elbow can be brought to the side when the

day, the dressings are inspected. The patient then is treated as for an epiphyseal separation in good position.

Complications. Impaction in poor position must be released. To secure reduction, considerable leverage may be necessary.

Failure to reduce by closed methods necessitates strong traction in abduction for from 3 to 5 days. If this fails, open operation, without internal fixation, must be performed without undue delay, since organization and callus formation proceed very rapidly in the young.

FRACTURES OF THE HEAD AND THE NECK OF THE HUMERUS

Anatomy and Etiology

The cylindrical humerus has an upper knoblike end. The shaft is strong cortical bone, while the upper end is spongy. The transition occurs at the surgical neck, which represents also the line of division between the attachments of the short rotators above and the powerful thoracic muscles, such as the pectoralis major and the latissimus dorsi, below (Fig. 503).

Dense fibrous tissue bridges the groove between the two tuberosities, and, in the canal so formed, the long biceps tendon passes upward to pierce the capsule, cross the joint space and become attached to the upper margin of the glenoid cavity (Fig. 504). The biceps tendon does not move during elevation, rather, the head and the neck of the humerus move on it as on a guide wire.

After fracture, both fragments remain threaded on the biceps tendon (Fig. 505). Tear of the tendon rarely is a complication. Commonly, some untorn periosteum and short-rotator tendon expansions also connect the fragments. Falls on the hand and the arm and sometimes direct violence cause these injuries. The fracture line is irregularly transverse, often with comminution or impaction (Fig. 506). The greater tuberosity often splits off as a separate fragment. The position of the arm and the direction of the fall often determine the displacement of the fragments. In only a few cases can the exact mechanics of displacement be determined.

Fig. 503. Showing the muscle attachments at the upper end of the humerus. Note the clear space at the neck.

Some shortening accompanies the fracture; this is a few millimeters when position is good, and possibly 3 or 4 cm. when the fragments overlap.

Diagnosis

Pain at the shoulder after a fall or a blow, with swelling and tenderness localized over the head or the neck of the humerus, and pain on elevation or rotation of the arm and on tapping the point of the flexed elbow must make the examiner suspect a fracture. On comparison with the uninjured side, deformity may be visible. The examiner grasps the head of the bone firmly with one hand and rotates the flexed forearm with the other (Fig. 507). If the head fails to rotate with the shaft, or if crepitus and increased pain are elicited, a definite diagnosis may be made. Ecchymosis along the medial side of the biceps muscle appears in from 24 to 48 hours.

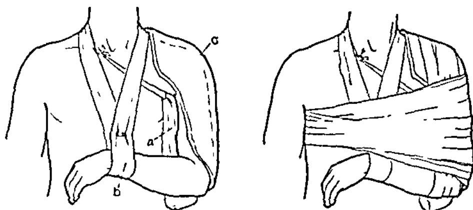


FIG. 502. Axillary pad, sling and swathe dressing. The axillary pad is made of 2 thicknesses of sheet cotton 20 x 8 in. A strip of bandage is laid across it, and the cotton is folded over it to make a pad 10 x 8 in. This is wrapped in gauze, powdered and placed high in the axilla (a). The strip of bandage is tied over the opposite shoulder. When it is necessary to hold the upper end of the humerus away from the chest, the pad is made thicker in the axilla. When moderate abduction of the arm is desired, it is made thicker at the elbow. The dressing is completed with a wrist sling (b) and a body swathe. A shoulder cap (c) of plaster or cardboard is added if there is any likelihood of displacement of the fragments.

of a fall, a blow or twisting the arm beyond its normal range of motion, followed by pain in the shoulder that is increased by motion, and swelling and localized tenderness leads to the diagnosis. Deformity and mushy crepitus may be present. Roentgen examination must be made to differentiate it definitely from fracture of the neck of the bone.

When displacement is slight or absent, roentgen examination may be negative. The diagnosis then must be made on the physical signs. After 2 or 3 weeks, films may show calcification beneath stripped-up periosteum.

Treatment. When little or no displacement has occurred, the arm is fixed to the side with an axillary pad, sling and swathe dressing (Fig. 502). The hand and the elbow are exercised daily from the beginning. Within 7 to 10 days, stooping exercises (Fig. 339) of the shoulder are started to prevent stiffness. After 3 weeks, no dressings are needed.

Any considerable displacement must be reduced. If there are any signs of pressure on the axillary structures, or if the position of the diaphysis is such as to endanger them, continuous traction in bed must be used.

Reduction. With sufficient anesthesia for relaxation, strong steady traction is made on the abducted arm for from 5 to 8 minutes. Then, while the traction continues, pressure on the outer or the inner side of the head or on the shaft (as indicated in Fig. 501), helps to secure alignment. Reduction may be impossible without open operation.[31]

After reduction, an axillary pad, sling and swathe dressing is applied. A plaster shoulder cap gives a little more security for active youngsters or when reduction is somewhat unstable (Figs. 502 and 520). On the following

is convenient to classify these fractures in 4 groups:

Fractures Without Displacement or With Unimportant Displacement of the Fragments

If no displacement of the fragments has occurred, no reduction is required. In a young person, an angulation of from 10° to 15° and less than one third diameter of sidewise displacement is unimportant; no disturbance of function and no deformity will result.

In older people, possibly an impaction with from 30° to 45° of angulation and less than two thirds diameter of sidewise displacement also may be considered to be unimportant, since little disturbance of function will result if treatment is carried out properly. The normal range of motion at the shoulder is so great that a loss of 30° of the full 180° is unimportant. The risk of anesthesia and the trauma of reduction should be weighed against the expected benefits in these cases.

When no reduction is indicated, the initial dressing remains undisturbed. If the patient's general condition warrants it, he may go home with instructions to apply an ice bag and to take a sedative as often as necessary. Acetylsalicylic acid, gr. x, and phenobarbital, gr. 1/4, every 3 or 4 hours, or even morphine sulfate, gr. 1/6, is prescribed. The patient should return in 24 hours for inspection of the dressing and of the extremity, thereafter, twice weekly will be sufficient. Full exercise of the hand and the wrist starts at once. After 2 weeks, a triangular sling is substituted for the other dressing, and daily stooping exercises of the shoulder and guarded exercises of the elbow may be started.

In elderly patients, the stooping exercises and the exercises of the elbow



Fig. 507. Examination for fracture of the neck of the humerus. The examiner grasps the head of the bone firmly with one hand and rotates the flexed forearm with the other.

should be started as soon as acute pain and swelling subside, usually within 3 to 5 days. A procaine injection at the site of fracture abolishes pain and muscle spasm, and permits even earlier exercising. Neglect of early exercise and prolonged immobilization cause persistent stiffness, pain and disability of the shoulder (Fig. 518).

The position of the fragments is verified by roentgenograms at the end of the first week. Further roentgen examination is not needed until it is desirable to determine callus formation, unless there is a sudden increase of pain at the fracture site, which may denote displacement of the fragments.

After 4 to 5 weeks, callus usually can be palpated, and tenderness is absent if union has occurred. The extent of union should be verified by roentgenograms. At this time, full use may be resumed, with the exception of those duties requiring considerable exertion, such as pushing, pulling and

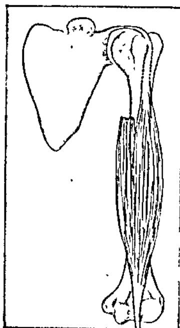




Fig. 504. (*Left*) Showing the tendon of the long head of the biceps, which is fastened securely in the bicipital groove.

Fig. 505. (*Right*) After fracture of the neck of the humerus, the fragments usually remain attached to the tendon If the tendon is made taut, the fragments tend to fall into alignment.





Fig. 506 (*Left*) Comminuted fracture of the neck of the humerus and the greater tuberosity in a 65-year-old woman. Reduction was not performed. The patient was treated with a sling and a swathe and early stooping exercises, an excellent result was obtained (*Right*) Showing the position of the fragments more clearly in the same fracture.

Treatment of Various Types

Immediately after the examination, the arm is immobilized in an axillary pad, sling, shoulder cap and swathe dressing (Fig. 502), and a roentgen examination is made The films are read at once to form a decision concerning further treatment. This will vary with the displacement of the fragments. In discussing treatment, it





FIG. 511 (*Left*). Reduction of a fracture of the neck of the humerus with the patient sitting.

FIG. 512 (*Right*). Reduction of a fracture of the neck or the shaft of the humerus with the patient in the supine position. The assistant makes traction by leaning backward. The surgeon, not shown, uses both hands to adjust the position of the fragments.

with or without slight comminution and with displacement beyond the limits described above. Overlapping may occur and may be associated with marked rotation of the head in relation to the shaft. In these cases, the head often lies in a position of abduction, external rotation and forward flexion (Fig. 508). The position of the shaft varies; usually, the deltoid pulls the upper end upward, and the pectoralis major pulls it inward. The elbow moves outward (Fig. 509). Invariably, the patient carries his forearm across his chest, and so brings the shaft into internal rotation. The upper end of the shaft may lie anterior or posterior to the head. Roentgen examination in two planes is necessary, the regular anteroposterior view being supplemented by a lateral view, taken through the body. In the low surgical neck fractures of children, the upper fragment may be abducted and flexed forward without much external rotation, the upper end of the shaft moving outward and the elbow inward. There are numerous other types of displacement, frequently with comminution.

Anesthesia. The anesthetic of choice is procaine hydrochloride (See Chap. 3). From 10 to 15 minutes must elapse before reduction is begun.

This anesthesia is particularly useful in the early cases seen within 24 hours after injury. After this period, clotting and organization interfere with diffusion, and edema, diffusion of blood along fascial planes and increased muscle spasm necessitate the greater relaxation obtained with general anesthesia. Fluoroscopic control should be used whenever possible, otherwise films must be made immediately after reduction and before application of the dressing.

Reduction. The method of reduction used by Howard and Eloesser[11] is as follows:

With the patient sitting upright, supporting the injured arm across the body with the opposite hand, a folded face towel is placed over the forearm just below the elbow. A 4-in. or 6-in. heavy muslin bandage is looped over the towel



FIG. 508 Fracture of the neck of the humerus. The head lies in the abducted position Alignment was obtained by bringing the arm into abduction and holding it there in an abduction cast

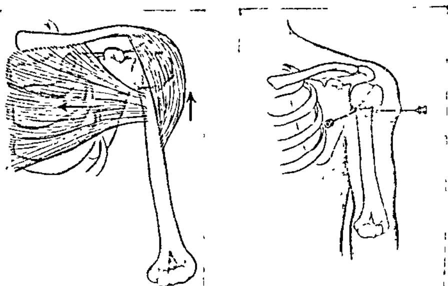
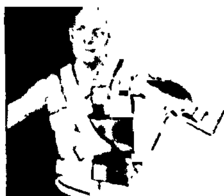


FIG. 509 (*Left*) Fracture of the neck of the humerus The head lies in abduction due to the unopposed contraction of the supraspinatus The shaft is pulled upward by the deltoid and inward by the pectoral muscles

FIG 510 (*Right*) Local anesthesia for reduction of a fracture of the neck of the humerus

twisting, which should be deferred for another month.

If a program of exercise can be followed, little formal physiotherapy need be used. In the early period of immobilization, heat and gentle massage with a mild counterirritant ointment for from 5 to 10 minutes This can be repeated twice daily. Exercises and massage must be continued until a full range of motion is regained.



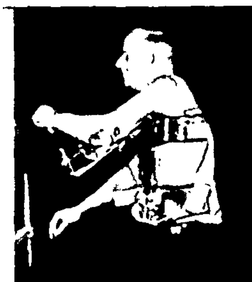


Fig. 513 (*Left*). Adjustable abduction splint arranged for continuous traction. Without the traction, the splint often is used for other lesions, such as rupture of the supraspinatus tendon. (Zimmer Manufacturing Co.

Fig. 514 (*Right*). Abduction splint, lateral view. Note that the arm lies well forward of the lateral position. (Zimmer Manufacturing Co.)

are then wrapped about the forearm, the arm and the chest until a cast of about $\frac{3}{16}$-in. uniform thickness has been made. The free ends of the sheet wadding and stockinet at the wrist, the opposite axilla and the waistline then are turned over the edges of the plaster and fastened with two additional turns of plaster bandage.

Since displacement of the fragments may occur during application of the cast, it is advisable to have an additional roentgen examination made as soon as the plaster has set.

Postreduction Care. The hand must be exercised from the beginning. After a week, the plaster may be removed from the dorsum of the forearm to permit active exercise of the forearm and the elbow. After 2 or 3 weeks, it may be cut open on the outer side of the arm to permit gentle exercise and massage of the shoulder. A roentgen examination is made at the end of 1 week to verify maintenance of position At the end of 4 to 6 weeks, callus formation is determined, both by palpation and by films, if it is adequate, the cast is removed entirely, and baking, massage and active use are started. The physiotherapy must be continued until there is a full range of painless motion.

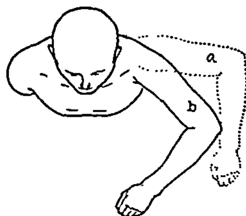


Fig 515 The correct position for the abducted arm as seen from above. (a) Incorrect position, in which the pectoral muscles are tense. (b) Correct position of muscle balance.

and tied in a sling, so that its lower end hangs from 8 to 12 in. from the floor. An assistant grasps the wrist of the injured arm and, bringing the forearm at right angles to the body in the sagittal plane (pointing forward) maintains right angled flexion of the elbow. The surgeon then places one foot in the sling, grasps the upper arm with both hands below the *line of fracture*, and slowly and steadily increases the amount of pressure on this foot. [Fig. 511.] It is often of advantage to have the patient on a stool, in order to use the lower rung as a fulcrum for the toe of the foot applying the traction force. This not only steadies the foot, but increases the amount of force one can use. The two hands grasping the arm below the fracture site are used to force the upper end of the distal fragment *laterally*, anteriorly, or posteriorly, as required by the displacement. In those fractures with marked abduction of the upper fragment, it is well to have an assistant bear down upon the upper fragment while traction is being applied.

This method makes use of the taut long biceps tendon as a guide for both fragments, it requires less force than traction in abduction, in which the tension of the pectoralis major must be overcome.

When only horizontal fluoroscopy is available, or when general anesthesia or the condition of the patient necessitates having the patient on his back, a slightly different method is used (Fig. 512). For countertraction, a swathe or webbing strap 6 in. wide is passed round the patient's chest and fastened to the table or to an assistant on the uninjured side. The forearm is flexed to a right angle, and a folded towel is placed over it just below the elbow. A heavy muslin bandage is tied on over the towel and then passed about the waist or the shoulder of another assistant, who then holds the forearm at a right angle and produces traction by leaning backward. The pull should be very steady and increased slowly over a period of from 5 to 8 minutes. The axis of traction may be in line with the body or in from 30° to 45° of abduction, as seems best. The surgeon *manipulates the fragments into alignment* by pressure, and the arm is taken slowly to the side. If the fragments remain in good alignment, the arm is fixed to the side with an axillary pad, a sling and swathe dressing and a shoulder cap (Fig. 502). Treatment then is continued as for a fracture in good position. In older patients, in whom shoulder stiffness is *feared much more than* elbow stiffness, the hanging cast (see page 691 and Fig. 525) makes a good dressing. The weight tends to maintain reduction, and the daily shoulder exercise prevents stiffness.

In some instances, displacement recurs when the arm is taken to the side. If satisfactory position can be maintained only in abduction, the arm *must be fixed in an abduction* cast or splint (Figs. 513, 514 and 516). The most favorable position is from 30° to 60° of abduction, about midway between the coronal and the sagittal planes, and midway between internal and external rotation (Fig. 515).

Application of an Abduction Cast. After washing the skin with alcohol and powdering it, a stockinet jacket is applied to the chest, and sheet wadding is wrapped round the body from the neck to below the iliac crests. Two plaster splints, 6 in wide by 3 ft. long and 1/8 in. thick, are made and laid on the arm from the hand over the elbow, up the arm to the shoulder and then across the back and the chest (Fig. 516). Six-inch plaster bandages

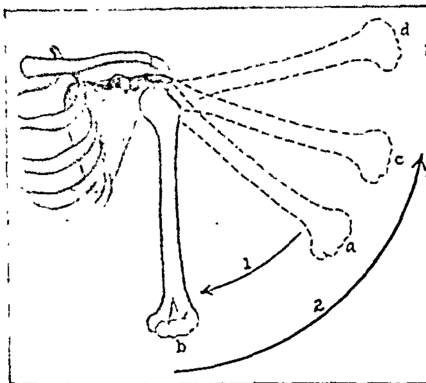


FIG. 517. When the supraspinatus is tense during abduction, sudden adduction (1) from the position at *a* results in avulsion of the greater tuberosity. The arm comes to the side, *b*. The tuberosity may be retracted as shown. When it is, the arm must be abducted (2) to the position shown in *c* or *d*.

Avulsion Fractures of the Greater Tuberosity

Avulsion fracture of the greater tuberosity is an uncommon injury, but it deserves extended description because of the disability that may follow it. The greater tuberosity is the point of insertion of the supraspinatus muscle, the primary elevator of the arm. The muscle works at great mechanical disadvantage, and the tuberosity is subject to relatively great tension during elevation.

Etiology. Fracture of the tuberosity frequently complicates dislocation at the shoulder (Fig. 493). The tuberosity with its attached taut supraspinatus tendon tears off or is pulled off. Usually it moves back into position when the dislocation is reduced. If the tuberosity remains retracted, there probably is an extensive rupture of the short rotator cuff

Avulsion fracture follows another type of violence, a fall against the side of the partly abducted arm (Fig. 517). The elbow is held away from the side to take the force of a fall against a wall or a floor. At impact, an abrupt tension is applied to the supraspinatus muscle and tendon and to the greater tuberosity. In older patients, the tendon, weakened by attritional changes or ischemia, tears either partly or completely. In younger people, the tuberosity snaps off. The unopposed tension of the supraspinatus muscle permits retraction of the fragment toward the scapula. When the fracture is complete and the retaining



FIG 516 Application of an abduction cast. (*Top, left*) A stockinet jacket and sleeve have been applied. (*Top, center*) Felt in position at the sides of the body and over the shoulders (*Top, right*) The molded plaster splints have been applied from the knuckles to the back (*Bottom, left*) Application of circular plaster. (*Bottom, center*) The stockinet has been turned back at the knuckles, the shoulders and the abdomen, and held with a few extra turns of plaster bandage. (*Bottom, right*) A piece of board is placed between the arm and the chest, and fastened with turns of plaster to prevent the breaking of the cast at the shoulder Extra plaster splints in the axilla and over the shoulder may be substituted for this

Extensively Comminuted Fractures

When extensive comminution and displacement are present, hospitalization for treatment by continuous traction usually is advisable. An exception to this may be elderly patients in whom some loss of shoulder function is unimportant. Many such patients can be treated satisfactorily by the hanging-cast method described on page 694, provided exercise is started from the beginning and is performed faithfully.

a stiff, atrophic and extremely painful shoulder (Fig. 518).

When the tuberosity has been retracted substantially by the supraspinatus, the arm is elevated fully with the wrist resting on top of the head, and a roentgen examination is made. If the approximation of the tuberosity is satisfactory, the arm is immobilized in this position by a light plaster dressing for 4 weeks (Fig. 519). The upper chest is covered with stockinet, which is brought up and sewn over both shoulders. A stockinet sleeve is slipped on to the affected arm from the wrist to the axilla, where it is sewn to the chest stockinet. A thin layer of sheet wadding then is made to cover the upper chest and both shoulders with several thicknesses in the opposite axilla. The length from the dorsum of the wrist over the point of the elbow to 6 in. beyond the axilla is measured, and a plaster splint, 6 in. wide and 1/8 in. thick, is made and applied over this area. The plaster is notched and folded over at the elbow, then bandaged to the forearm and the upper arm with 2 or 3 layers of plaster bandage. Six-inch plaster bandage is applied about the upper chest and round the affected shoulder and the plaster splint, with a narrow band over the opposite shoulder. When the thickness of the cast is about 3/16 in., the ends of the stockinet are folded over the margins of the plaster and fastened with a few extra layers of plaster bandage.

At the end of 4 weeks, the plaster dressing is removed and the arm is lowered very slowly to the side. Stooping exercises, heat and massage are started immediately and continued until full function returns. This may take from 4 to 12 weeks.

When the tuberosity has been retracted so far that approximation cannot be secured, the end result may be marked impairment of the ability to elevate the arm. Open operation must be considered without undue delay.

Complications of Fractures of the Head and the Neck of the Humerus

Injury to the circumflex, or axillary, nerve, as manifested by deltoid paralysis, may occur. The axillary blood vessels and the brachial plexus may be injured. Additional fractures or soft-tissue injuries may be present.

Failure to reduce displacement and rupture of the biceps tendon may make it necessary to operate.

FRACTURES OF THE SHAFT OF THE HUMERUS

Fractures of the shaft of the humerus may result from falls on the hand and the forearm, from direct violence, such as a blow with a club, from muscular violence during wrestling, or from throwing a ball. The fracture may be transverse, oblique or comminuted. Complete displacement and overriding of the fragments are common. The biceps and the triceps go into spasm and increase the deformity.

Diagnosis

Deformity makes the diagnosis easy. There may be shortening, angulation, thickening and irregularity of the shaft. Normally, the external epicondyle lies in the plane of the greater tuberosity. When this relationship changes, rotary displacement has occurred. Tenderness at the fracture site usually is acute and well localized. After a few hours, swelling and muscle spasm are present. Later, ecchymosis appears. Anteroposterior and



FIG 518. This patient had a fracture through the left greater tuberosity in good position except for some roughening. The arm was held at the side for about 4 weeks without motion. (*Left*) Shows the atrophy of the deltoid and the spasm of the trapezius. (*Right*) Shows the atrophy of the supraspinatus and the infraspinatus. The patient now must be treated as for chronic adhesive subacromial bursitis (frozen shoulder) (pp 460, 468).



FIG. 519 Abduction plaster dressing for displaced fracture of the greater tuberosity of the humerus

periosteum is torn through, it may come to rest in the position that it normally would occupy only in full elevation of the arm However, very often enough periosteum remains untorn to retain the fragment in relatively good position. Since the tuberosity forms part of the floor of the subacromial bursa, hemorrhage and exudation into the bursa follow the injury.

Diagnosis. As may be expected, the clinical picture resembles that of acute traumatic subacromial bursitis and rupture of the supraspinatus tendon. Spasm of the shoulder muscles, severe pain on elevation of the arm and tenderness over the bursa are present. Fracture may be suspected from the agonizing localized tenderness over the tuberosity and from the presence possibly of slight notching at the site of the tuberosity when a large bone fragment has been detached and retracted. Clear films must be obtained to determine the degree of displacement.

Treatment. When the fragment remains in good position, immobilization in slight abduction for from 4 to 6 weeks may be desirable. A thick triangular axillary pad, base down, a sling and a swathe make a satisfactory dressing. Daily stooping exercises and heat and massage should be started after 1 or 2 weeks and continued regularly until full function returns. Failure to begin exercises early and continue them regularly often results in

interrupted immobilization appears to be a safe minimum. At the end of this period, the splints are removed, the part is examined for callus formation, and the findings are verified by films. If union is satisfactory, baking, massage and graduated exercises are prescribed and are continued until the maximum return of function is obtained.

If, after 8 weeks, callus formation is meager and if the fracture line still shows on the films, an axillary pad, a sling and a swathe dressing are applied. Hot soaks, massage and continuous motion of the elbow are begun in addition to the stooping exercises of the shoulder. Active use is not started until there is reasonably solid union.

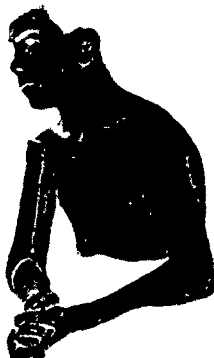


Fig. 522. Sugar tong plaster splint for fractures of the lower part of the shaft of the humerus. The splint is fastened with bandage and adhesive. A sling and a swathe complete the dressing

Treatment of Transverse Fractures in Bad Position

Transverse and slightly oblique fractures of the shaft offer more difficulty in management when overriding of the fragments occurs.

When the level of fracture lies above the insertion of the deltoid, this muscle tends to bring the lower fragment upward and outward with the assistance of the biceps and the triceps, while the upper fragment is adducted by the pectoralis major and the latissimus dorsi (Figs. 523, 524). When the level of the fracture lies below the insertion of the deltoid, the action of the muscle is counterbalanced more or less by the action of the adductors, and displacement of the fragments is variable. Spasm of the biceps and the triceps tends to produce and maintain overriding.

A simple rule for reduction is to bring the axis of the lower fragment, which can be controlled easily, into line with the axis of the upper fragment. Sufficient traction overcomes the shortening, and gentle manipulation secures apposition. Occasionally, angulation may be increased momentarily to bring the edges of the fragments into apposition, and reduction then is secured by leverage.

Facilities for fluoroscopy or the immediate development of films are very helpful. If not more than 24 or 36 hours have elapsed since the accident, local anesthesia is to be preferred. Brachial plexus block anesthesia (pp. 46-49) also is satisfactory, and it may be used even longer after the accident. Both types have advantages. The vertical fluoroscope can be used. Reduction may be performed more easily, and the immobilizing dressing





Fig. 520. Axillary pad, sling, swathe and cardboard shoulder cap dressing for fracture of the shaft of the humerus in good position. The shoulder cap of wet corrugated cardboard padded with cotton is light and easily available, and as it dries it molds and hardens.



Fig. 521 Roentgenogram of fracture of the shaft of the humerus in patient shown in Figure 520

lateral roentgenograms should be taken.

Treatment of Fractures in Good Position

If there is sufficient apposition for stability, slight degrees of angulation and rotary deformity may be corrected without anesthesia at the time of applying the immobilizing dressing. Incomplete fractures require only an axillary pad, a sling and a swathe dressing with a shoulder cap (Figs. 502 and 520.) Otherwise, a plaster sugar-tong splint, 6 in. wide, about 3 ft. long and ¼ in. thick, is made.

With the forearm at a right angle, it is applied from the medial side of the axilla down the inner side of the arm, across the extensor surface of the forearm at the elbow and up the outer side of the arm to the top of the shoulder (Fig. 522). A gauze bandage then fastens the splint securely. The whole arm is dressed at the side with an axillary pad, a sling and a swathe. Another roentgen examination should be made in 1 week to make certain that the fragments have not slipped.

The patient must exercise his hand from the beginning. After 1 or 2 weeks, the swathe may be removed 2 or 3 times daily for stooping exercises of the shoulder (Fig. 339).

Transverse fractures of the shaft of the humerus unite slowly at best. Delayed union and nonunion in these cases are not rare. Eight weeks of un-



FIG. 525. Hanging cast. Stooping exercises of the shoulder shown were begun 4 days after the injury.

In some circumstances, general anesthesia may be preferred for reduction. The patient is placed on a fluoroscopic table (p. 681). Steadily increased traction is made on the flexed forearm until the shortening disappears. This takes from 5 to 15 minutes. The fragments are moved into apposition, and their position is determined by fluoroscopy. When the position becomes satisfactory, the traction is decreased, but it is maintained until the immobilizing dressing is completed and the patient can sit up. The plaster sugar-tong splint, axillary pad, sling and swathe dressing are used unless an abducted position is required.

For older patients, the hanging cast (Fig. 525) has some advantages; while it does not immobilize the fracture site well, it does permit stooping exercises from the beginning. The usual late stiffness and pain at the shoulder are prevented. There also is less restriction and compression of the chest. Treatment is continued as for fractures in good position.

If a good position of the fragments cannot be obtained or maintained, continuous traction must be instituted. Open reduction may be advisable in some cases.

Treatment of Oblique and Comminuted Fractures

When shaft fractures are oblique or severely comminuted, it becomes obvious that the fragments cannot be maintained in position by the usual methods of splinting. Continuous traction and suspension then become necessary. The guiding principles are:

1. Sufficient traction to overcome shortening and no more. A gap between the fragments invites a delay in union or nonunion.

2. The direction of traction must be such that the axes of the proximal and the distal fragments coincide.

3. The flexed forearm is brought to the position of rotation assumed by the uncontrolled proximal fragment, usually midway between internal and external rotation.

Continuous traction may be made

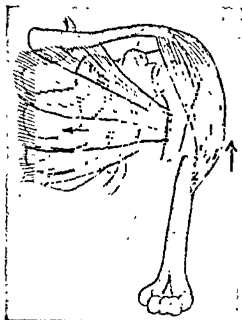


Fig. 523. Fracture of the shaft of the humerus between the pectoralis and the deltoid insertions. Shows muscle pull.

may be applied with much less difficulty and less danger of displacing the fragments, with the patient seated than in the recumbent position.

Local anesthesia is induced by injecting 1 per cent procaine solution on the lateral and the medial aspects of the arm at the level of the fracture. From 10 to 15 minutes should elapse before manipulations are begun. The patient is seated on a stool, and reduction is done as described on pages 683-684. The surgeon's foot makes traction on the flexed forearm. When the shortening disappears, the fragments can be moved into apposition The traction must be slow and steady, and the manipulations must be gentle. The position of the fragments is determined by fluoroscopy, and additional correction is made if necessary. If there is no angulation with the arm at the side, gentle traction is maintained while a plaster sugar-tong splint and an axillary pad, a sling and swathe dressing are applied as described on page 690. If the lower fragment can be aligned with the upper fragment only in a position of abduction, an abduction splint or cast is applied (pp. 684-686) with the arm in sufficient abduction and about halfway between the coronal and the sagittal planes.



Fig. 524. Fracture of the humerus, approximately between the insertion of the deltoid and the pectoralis major The marked angulation, which was present with the arm in abduction, was corrected when the arm was taken to the side.

complication should be suspected when crepitus is not felt readily on manipulation of the fragments.

Involvement of the radial (musculospiral) nerve may occur. This lies in direct contact with the middle third of the shaft of the bone as it winds round from behind. Involvement produces wrist drop and sensory changes. If evidence of nerve injury presents itself at the original examination, contusion or laceration may have occurred. Later involvement usually means constriction by scar or callus.

Fractures in the lower third of the shaft frequently angulate. Ordinarily, the biceps aids the forearm supinators in opposing the strong pronators. When the humeral shaft loses its rigidity, the supinating effect of the biceps diminishes, and the pronators then hold the forearm and the elbow pronated. If one supinates the forearm fully, rotation may occur at the fracture site with angulation of the fragments, the angle open medially (Fig. 526). The pronators relax in full pronation, overcoming this effect. Pronation must not be forced or the reverse effect may follow.

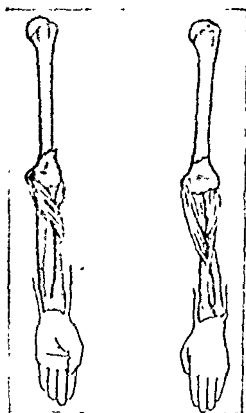


Fig. 526. Fracture at the lower end of the humerus. When the forearm is supinated, the fracture site becomes an accessory point of rotation. Pronation relaxes the pronators, and the angulation disappears.

FRACTURES OF THE HUMERUS AT THE ELBOW

The strong cylindrical shaft of the humerus broadens, thins out and bends forward as it approaches the elbow. The articular surfaces resist fracture, but the less dense, spongy bone immediately above has hollows for the coronoid process of the ulna anteriorly and for the olecranon posteriorly and, therefore, becomes the vulnerable level.

Epiphyseal Development (Fig. 527)

The epiphyses at the lower end of the humerus vary considerably in time of appearance, contour and time of fusion to the shaft. Very often in childhood the roentgenograms show irregularities that must not be interpreted as fractures except after comparison with the opposite normal side.

The fragility of the lower end of the humerus varies with age; the forward bend is greater in childhood. A lateral view of the elbow shows the capitellum concentric with the sigmoid fossa of the ulna. Up to 9 years of age, a line bisecting the humerus in its long axis passes behind the posterior border of the capitellum; after this, the line has two thirds of the lower epiphysis anterior to it. The axis of the capitellum lies at an angle

with the patient either confined to bed or ambulant. In the ambulatory patient, an abduction splint or a hanging cast may be used.

Abduction Splint. The abduction splint (Figs 513, 514) should be applied with the arm in sufficient abduction for alignment of the fragments, about midway between internal and external rotation, and halfway between the coronal and the sagittal planes (Fig. 515). Strong traction should be made for 24 hours, after which time a roentgen examination is made. If the position is good, the traction is decreased gradually during the next few days.

The Hanging Cast. Good position of the fragments often can be obtained by the use of the hanging cast (Fig. 525) The method is particularly useful in elderly patients, in whom considerable angulation and shortening can be permitted. It allows immediate exercise and causes little restraint of the chest

A plaster sugar-tong splint, 6 in. wide and from 18 to 24 in. long, is made and applied from the axilla down the medial side of the arm, beneath the elbow and up the outer side of the arm until it is above the insertion of the deltoid. A second splint, 4 in. wide and from 24 to 30 in. long, is applied from the knuckles along the extensor surface of the semipronated forearm, round the back of the elbow and then along the flexor surface of the forearm to the flexion crease of the hand. Two 4- or 6-in. bandages then are applied to make the cast, with a plaster loop just proximal to the wrist. Next, a neck sling is passed through the loop and fastened so that the forearm lies horizontally or slightly higher than the horizontal The patient must allow the cast to hang freely and must not support the elbow with his knee when sitting or with pillows. He will be obliged to sleep in a semireclining position for 2 or 3 weeks.

On the following day, the position of the fragments is determined by fluoroscopy or films. Traction may be increased if necessary by adding weight at the elbow with a small lead plate or more plaster. Angulation should be corrected by lengthening or shortening the sling if it is seen in the anteroposterior view, that is, the angle open medially or laterally; if the angle is open forward or backward, a thick pad is strapped to the medial aspect of the elbow or the upper arm as needed If overtraction is present, a lighter cast may be needed.

The hand should be exercised from the beginning; stooping exercises of the shoulder may be started immediately (Fig. 525) and continued 3 times daily After removal of the cast, hot soaks and massage will help to diminish stiffness at the elbow.

The position of the fragments must be determined 1 week later and again in a week to 10 days. After 3 or 4 weeks, the tendency for the fragments to slip is much less, and further roentgen examinations may be postponed until clinical union appears The cast may be removed when clinical and roentgen evidences of union are present, which usually is in 5 to 8 weeks A sling may be used for a short time until the elbow can be extended. Physiotherapy is continued as outlined.

Complications of Fractures of the Shaft of the Humerus

Interposed muscle may prevent reduction and require operation. This

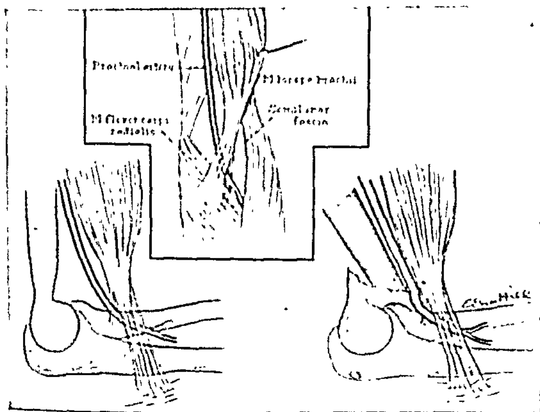


FIG 529. Showing the brachial artery passing beneath the semilunar (bicipital) fascia. The projecting sharp end of the upper fragment of the humerus may compress or sever the vessel

and tendon, and passes under an aponeurotic slip from the tendon, the bicipital fascia, just below the bend of the elbow (Fig. 529). It is accompanied by the median nerve The radial nerve lies between the brachialis anticus and the brachioradialis, anterior to the external condyle and the head of the radius. The ulnar nerve lies posteriorly in a groove between the internal condyle and the olecranon process.

Etiology and Displacement

In the adult, falls on the hand with the forearm extended may cause posterior dislocation at the elbow (Fig. 530, a and b). In children, supracondylar fracture of the humerus of the extension type occurs more often (Figs. 529 and 530, c). The line of fracture is more or less transverse in the anterior view, but frequently it is oblique when seen from the side, that is, running from in front upward and backward. The lower fragment moves backward and upward as the expanded thin end of the shaft moves downward and forward into the antecubital fossa, where it may tear or compress the brachial artery and the median nerve or the radial nerve. It may even protrude through the skin. Lateral and rotary displacement also occurs.

When the fracture follows a fall on the flexed elbow, the uncommon flexion type is present (Fig. 530, d and e). The fracture line runs from behind upward and forward, and the lower fragment moves upward and forward.

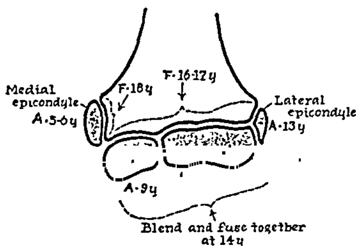


Fig. 527. Epiphyses at the lower end of the humerus. (A) The time of appearance of the centers of ossification. (F) The time of fusion of the epiphysis. The trochlear, the capitellar and the lateral epicondylar epiphyses fuse together at 14 years of age, and unite to the shaft at from 16 to 17 years of age. The epiphysis of the medial epicondyle fuses to the shaft independently of the others

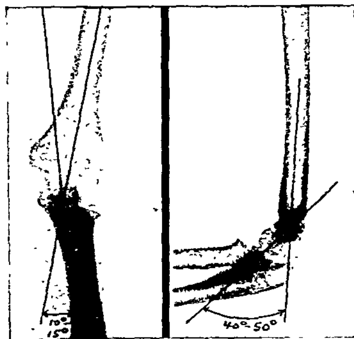


Fig. 528 The elbow before 9 years of age. In the lateral view (*right*), a line bisecting the humerus in its long axis passes behind the posterior border of the capitellum. After 9 years of age, about two thirds of the capitellum lies anterior to this line. A line bisecting the capitellum and at right angles to its base makes an angle of from 40° to 50° with the first line. In the anterior view (*left*), the carrying angle is shown as the angle between the long axis of the humerus and the long axis of the ulna, from 10° to 15°.

of 130° to the long axis of the shaft. With the forearm extended and supinated, the ulna can be seen to bend outward from the long axis of the humerus to the carrying angle, about 10° (Fig. 528).

Anatomy

The brachial artery and the ulnar, the median and the radial nerves may become involved in fractures at the elbow. The brachial artery lies at the medial border of the biceps muscle

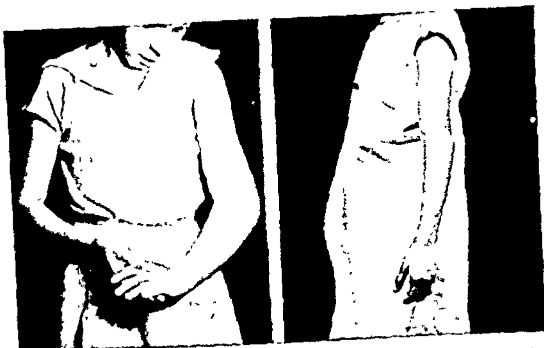


FIG. 531 (*Left*). Supracondylar fracture of the left humerus without displacement. Note the marked swelling. The dressing for this fracture is shown in Figure 551.

FIG. 532 (*Right*). Deformity produced by a supracondylar fracture, extension type.

signs are swelling (Fig. 531), local tenderness and pain on motion. In very young children, before the ossification centers appear, the films may be negative, even after extensive injuries, but treatment should be instituted as for fracture, since roentgen signs of epiphyseal separation may not be apparent until later.

When displacement of the fragments has occurred, the diagnosis of fracture may be made more readily. In addition to local tenderness and swelling, there may be visible (Fig. 532) or palpable deformity of the bones. To differentiate fracture from posterior dislocation at the elbow, the epicondyles and the tip of the olecranon are palpated and compared with the normal side. The tip of the olecranon is the apex of a triangle, of which a line between the epicondyles forms the base (Fig. 533). With the forearm flexed to a right angle, the triangle lies in the plane of the long axis of the humerus. With the forearm extended, the olecranon lies directly behind the line betwen the epicondyles. This relationship is altered characteristically in posterior and sidewise dislocations at the elbow. In extension fractures, the lower end of the shaft may be palpable in the antecubital fossa; in flexion fractures, it appears over the olecranon, which has moved forward with the lower fragment. A difference in the contour of the epicondyles on comparison with the normal side suggests epicondylar or condylar fracture, as does any lateral mobility of the joint, which normally is almost rigid in this plane.

A history of dislocation in a child, reduced by a layman, with marked restriction of motion and pain over the medial aspect of the elbow, re-

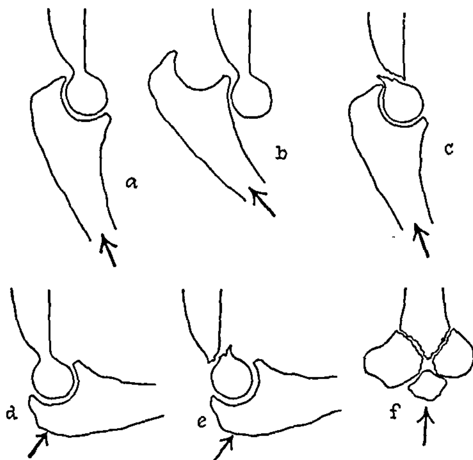


Fig 530. The mechanism of fractures at the elbow. (a) The common type of thrust during falls with the elbow extended. (b) In adults, the posterior dislocation that tends to occur (c) In children, the extension type of supracondylar fracture (d) The direction of the thrust in falls on the point of the flexed elbow and (e) the flexion type of supracondylar fracture that results. (f) Falls on the olecranon that tend to wedge it between the trochlea and the capitellum, and to fracture one or both.

Falls on the flat of the ulna wedge the olecranon between the condyles, the result being the T and the Y types of fracture (Fig 530, f).

Falls which put the medial side of the elbow on tension or make sudden tension on the flexor-pronator muscles may result in avulsion of the medial epicondyle, this same violence causes lateral dislocation at the elbow joint. The joint space widens from tension, and the epicondyle, drawn downward and medially by the pronators, may fall into the joint and be caught when the abrupt tension stops.

Falls on the olecranon that thrust the olecranon sidewise and upward account probably for the single fractures of the trochlea or the capitellum

Diagnosis

Aside from avulsion of the medial epicondylar epiphysis, simple epiphyseal separation is rare.

When fracture or epiphyseal separation occurs without displacement, the



FIG. 535 (*Left*). Plaster splints for fractures at the elbow
FIG. 536 (*Right*). The splints are fastened with a firm bandage of gauze. When the swelling subsides, the gauze is trimmed off, and circular plaster converts the splints into a cast. An unpadded cast may be made at once by applying plaster about the splints while they still are soft and wet.

complications are present, treatment is simple. The internal right-angled splint (Fig. 531) may remain, or, preferably, plaster splints may be applied from the hand to the axilla (Fig. 535) A snug flannel or elastic bandage helps to immobilize and aids in controlling swelling. Whether present or anticipated, swelling is controlled further by elevation of the extremity to the shoulder level on pillows and the application of ice bags for from 24 to 48 hours after injury. As soon as the swelling subsides, in about 3 to 5 days, an unpadded cast (Fig. 536) is applied from the axilla to the knuckles, with the forearm at a right angle and in partial pronation. Full active use begins immediately. The patient returns on the following day to have the cast inspected and to report if pain is present; thereafter a weekly visit suffices. At the end of 4 to 5 weeks, depending on the patient's age and the type of fracture, the cast is removed and full use is urged. Adults may have a little swelling of the forearm for a few weeks, which, along with stiffness, may be diminished by a daily hot soak and gentle massage. No forcible manipulations should be used.

For young children, the horse-collar dressing (Fig. 537) in the flexed position may be used instead of the splint and the cast. A satisfactory dressing for the very young may be made as shown in Figure 538.

Treatment of Fractures with Displacement

The elbow functions as a hinge joint. The axis of the hinge, measured on the outer side, lies at an

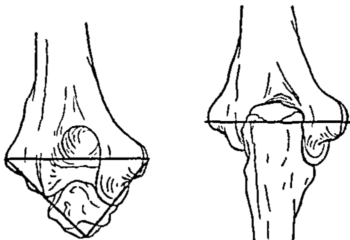


FIG. 533. Posterior aspect of the elbow. In extension, the tip of the olecranon is in line with the epicondyles. In flexion, the 3 points make a triangle.

quires accurate comparison of both inner epicondylar epiphyses and films of both sides. The inner epicondyle may lie in the joint space.

A suspicion of any complication warrants hospitalization. Compounding is an obvious and urgent complication. A diminished or absent radial pulse demands emergency care. Rapid swelling of the elbow and the forearm suggests extensive soft-tissue damage and venous obstruction. A careful examination of motor power and sensory function must be made and recorded.



FIG. 534. Snug flannel bandage, internal right-angled splint and wrist sling. Flexion to a right angle is not obtained because of swelling The upper end of the splint should come closer to the axilla (Fig. 559, *center*)

PRELIMINARY CONSIDERATIONS IN TREATMENT

The objectives of treatment are (1) the prevention of interference with circulation and of Volkmann's contracture (Fig. 547); (2) the prevention of nerve injuries; (3) alignment of the fragments to prevent deformities and loss of function; and (4) prevention of myositis ossificans, extensive fibrosis and persistent muscle spasm.

When the examination is completed, a snug pressure bandage is applied about the elbow, and the joint is immobilized in an internal right-angled splint (Fig. 534). This splint casts no confusing shadows in the roentgenograms. The arm is elevated when the patient is not walking, and the region of the elbow is surrounded with ice bags. The splint is maintained until a decision is made concerning further treatment.

TREATMENT OF UNCOMPLICATED FRACTURES IN GOOD POSITION

When displacement of the fragments is absent or negligible and when no

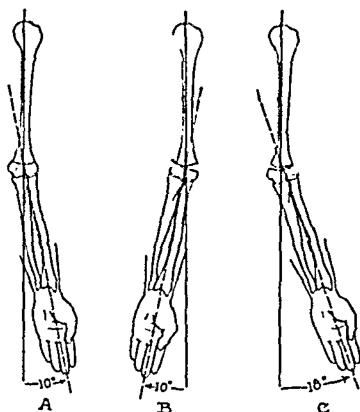


FIG. 539 The effect of sidewise displacement of the lower humeral fragment on the carrying angle. (A) Normal, (B) medial displacement and (C) lateral displacement.

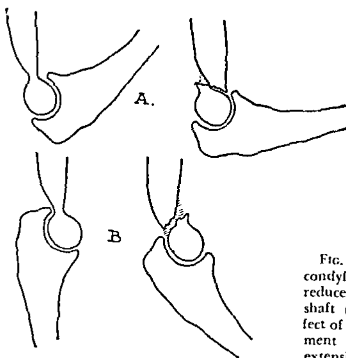


FIG. 540 Loss of mobility in supracondylar fractures. The effect of unreduced forward displacement of the shaft (A) is loss of flexion. The effect of unreduced backward displacement of the shaft (B) is loss of extension.



Fig 537. Horse-collar dressing for elbow injuries. A piece of wide rubber tubing is cut to fit round the neck, and another is cut to fit the wrist Bandage or tape is threaded through each piece of tubing and tied so as to hold the arm in acute flexion.

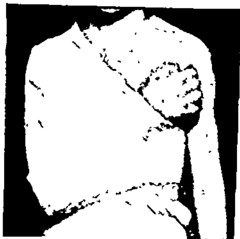


Fig 538. A body-swathe type of dressing useful for undisplaced shoulder, humerus and elbow fractures in small children When covered with plaster, it makes a light and comfortable cast A thin gauze pad is placed in the crease of the elbow, and a large pad is placed between the chest and the arm and forearm. For elbow fractures, a preliminary adhesive strapping is applied to hold the forearm flexed on the arm.

angle of about 80° with the long axis of the humerus. The forearm deviates outward at the carrying angle. Displacement of the lower fragment medially diminishes or reverses the angle, displacement laterally increases it (Fig. 539)

Full flexion and extension depend on the thickness of the hinge. Unreduced forward or backward displacements heal with thickening, and motion is blocked (Fig. 540). Rotary displacement has this effect as well as that of changing the distal axis.

The ulna and the radius flex concentrically on the axis of the hinge. Fractures between the trochlea and the capitellum may change their position in the long axis and affect the carrying angle, they also may change their anteroposterior position so that they rotate on different axes with limitation of motion (Fig. 541)

The brachial artery and the median nerve pass downward along the me-

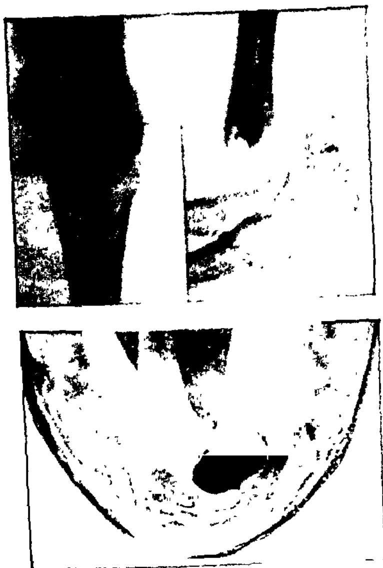


Fig. 512. Supracondylar fractures (*Top*) Showing the marked displacement visible in the lateral view (*Bottom*) Showing successful reduction.

3. Y, T and comminuted fractures with displacement.

4 Fractures of the trochlear or the capitellar side alone which are unsuitable for manipulation because of swelling, nerve injury or wide displacement.

Hospitalization for continuous traction becomes the method of choice:

1. When manipulation fails to reduce.

2. When the fragments cannot be held by splinting.

3. When excessive swelling or diminished radial pulse follows reduction and immobilization.[8]

Hospitalization and open operation are urgent:

1. For compound fractures.

2. When the radial pulse does not return after 30 to 45 minutes in continuous traction.

3. When excessive swelling, uncontrolled by continuous elevation and traction, threatens the venous return.

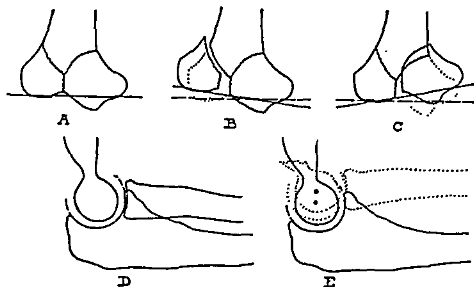


FIG. 541 The effect of displacement of the trochlea or the capitellum. (A) Normal contour of the articular surface. (B) Capitellar fracture; the forearm would shift to the outer side with increase in the carrying angle (C) Trochlear fracture; the carrying angle would be decreased or reversed (D) Normally, the axes of flexion of the ulna and the radius are concentric. (E) When the capitellum is displaced, the axis of flexion of the radius moves proximally; the 2 bones rotate on different axes, and motion becomes limited.

dial side of the biceps; then they pass through an almost rigid canal formed by the ulna, the radius and the interosseous membrane below, the biceps tendon laterally and the bicipital fascia medially. The lower end of the shaft may come down far enough to cause pressure on the artery (Fig. 529), or circulation may be obstructed when the tension in the antecubital space increases after extensive soft-tissue injury.

Reduction

Displacement of the fragments *threatens the* blood *supply*, *the nerve* supply and the function and the appearance of the arm.

Manipulation and immobilization is the method of choice in:

1. Simple supracondylar (Fig. 542) and transcondylar fractures which are uncomplicated by excessive swelling and bleb formation, by actual or threatened interference with the blood supply, as determined from the radial pulse, or by obliquity of the fracture line.

2. Longitudinal fractures of the trochlear or the capitellar side alone, if there is some prospect of successful reduction.

3. Simple epicondylar fractures.

This group may be reduced and treated safely in ambulatory patients.

Hospitalization for continuous traction is the method of choice in:

1. *Actual or threatened* interference with the blood supply.

2. The presence of severe swelling and bleb formation. (The swelling may defeat reduction, and the trauma of reduction may increase the swelling further.)



FIG. 518 Unpadded cast for elbow fractures. Note that the plaster is trimmed to allow full use of the hand

good position (p. 700). The splints may be converted later into an unpadded cast (Fig. 518) when the danger from swelling is over.

When reduction of a simple posterior displacement of a lower fragment is stable and maintained easily by simple flexion, the horse-collar dressing (Fig. 537) in the Jones position is satisfactory. A posterior molded plaster may be used if additional security is required. A powdered cotton pad should be placed in the crease of the elbow to avoid maceration of the skin. The untorn periosteum and the tense triceps make good splints.

Technic of the Unpadded Cast (Figs. 535, 536). An assistant holds the arm in the right-angled, partially pronated position, and the length from the knuckles over the point of the elbow and up the back of the arm to the axilla is measured with a strip of bandage. A 4- or 6-in. 5-yd. plaster bandage is dipped and then rolled out to make a plaster splint the desired length, and the splint is laid on the arm as indicated. It is notched and folded over at the bend of the elbow. A second splint 4 in. shorter is made and applied from the crease in the palm over the flexor surface of the forearm and up the front of the arm. One or two plaster bandages then bind the two splints together to make a cast. It is molded well over the elbow and the wrist, and trimmed to allow full use of the fingers, the thumb, and the shoulder (Fig. 518).

Manipulation of Transcondylar Fractures

When the fracture level lies low, so that the lower end of the proximal fragment is the very thin portion of the bone, traction and suspension rather than manipulation must be considered. Accurate reduction is very difficult, and residual displacement means trouble later.

Manipulation of Supracondylar Fractures, Flexion Type

In these cases, the lower fragment is displaced forward. Reduction may be effected by traction on the flexed semipronated forearm. When shortening has been overcome and lateral displacement corrected, the surgeon presses the shaft forward and the articular fragment backward, and attempts to engage the fragments. When this can be done, the traction is continued, and plaster splints held in place by a snug bandage are applied (Fig. 535).

Operation is indicated:

1. In certain Y, T, trochlear, capitellar and epicondylar fractures otherwise irreducible.
2. In irreducible supracondylar fractures.

Reduction of displacement is done best, without delay, even in the presence of considerable swelling. Alignment of the fragments increases the soft-tissue space and helps to reduce swelling by reducing the pressure on veins and lymphatics.

Anesthesia

For children, general anesthesia is preferred. Good relaxation makes it easier to align the fragments and causes less soft-tissue trauma; therefore, ether or Vinethene is chosen. For adults, local infiltration of the hematoma with 20 cc. of 2 per cent procaine or brachial plexus block anesthesia may be used. The latter is preferred.

Roentgen Control

Expert fluoroscopy before and after reduction is an invaluable aid. Continuous fluoroscopy during reduction is unnecessary and inadvisable. Films that are developed and read immediately are sometimes superior to fluoroscopy. In any event, the position of the fragments should be recorded on films immediately after application of the immobilizing dressing.

Manipulation of Supracondylar Fractures, Extension Type

The patient lies supine, with a wide strap about the upper chest fastened to the table or to an assistant for countertraction. For a fracture of the right arm, the surgeon clasps the patient's hand in a normal grip and makes steadily increased traction on the semipronated hand for 4 or 5 minutes while his left hand palpates the fragments. Slight hyperextension may be needed to release impaction. When the shortening has been overcome, the alignment is adjusted laterally, and the left hand is placed on the arm with the fingers anterior on the shaft and the thumb posterior on the lower fragment. The thumb makes strong pressure to engage the fragments, and the semipronated forearm is brought forward into acute flexion. While gentle thumb pressure is maintained, gentle motion of the elbow tests the stability and the alignment. The reduction then is inspected under the fluoroscope and repeated if necessary. Failure to obtain or maintain reduction indicates obliquity of the plane of fracture, and suspension and continuous traction must be instituted.

For more muscular patients, more effective traction may be produced with the pronated forearm flexed to a right angle. After shortening has been overcome by 5 to 8 minutes of traction, any sidewise displacement is corrected by direct pressure. The surgeon then places the palm of one hand beneath the olecranon posteriorly and the other hand over the arm anteriorly, and reduces the posterior displacement by direct pressure.

Immobilization. Most often, a position of right-angled flexion or moderate acute-angled flexion maintains the position of the fragments. While the surgeon holds the arm, two plaster splints, long enough to reach from knuckles to shoulder, are made. They are applied as shown in Figure 535. The splints are held in place with a snug bandage, and the arm is supported by a wrist sling. The patient then is treated as for a fracture in

More often than not, the fracture requires open operation.

Manipulation of Fractures of the Capitellar Side Alone (Fig. 511)

This fragment may move upward and rotate considerably, with increase in the carrying angle. Reduction is attempted by traction in hyperextension with adduction of the forearm on the humerus, followed by pressure on the fragment and flexion of the forearm in supination. The arm is splinted as for a fracture of the trochlear side. Open operation frequently is necessary.

Manipulation of Fractures of the Inner Epicondyle

Avulsion of the inner epicondylar epiphysis may be a complication of lateral dislocation of the elbow, especially in childhood. Isolated fracture of the epicondyle also occurs from direct violence (Fig. 515). Its displacement varies. Pronation of the forearm and direct pressure may reduce the displacement. When the epicondyle is caught in the joint space, the forearm is supinated and the elbow, the wrist and the fingers are extended. The forearm then is abducted in order to increase the gap between the trochlea and the ulna; this allows the epicondyle a free route of exit from the joint as it is pulled by the tension of the flexor-pronator muscles that originate from it. Some surgeons prefer to operate immediately when the fragment is in the joint space, or when ulnar nerve injury is present,[25] without attempting closed reduction.

Manipulation of Fractures of the Capitellar Epiphysis (Fig. 546)

McLearie and Merson[18] believe that this fracture does not occur by avulsion, but when posterolateral dislocation carries the fragment backward: clinically, no dislocation appears to be present, because the dislocated joint surfaces fall forward approximately into their normal position, and the fragment lies anterior to the humerus. They advise closed reduction by redislocating the elbow posterolaterally, followed by reduction, after which the fragment settles accurately in its bed: the fragment itself does not require to be pressed into position, but care



Fig. 515. An 11-year-old child fell from a bicycle on to the right elbow. The symptoms were pain, swelling, limited motion and marked tenderness over the medial epicondyle. The diagnosis was a transcondylar fracture and slight separation of the medial epicondyle. A splint and pressure dressing were applied for 5 days, after which an unpadded cast from the knuckles to the axilla was maintained for 3½ weeks. The result was excellent.

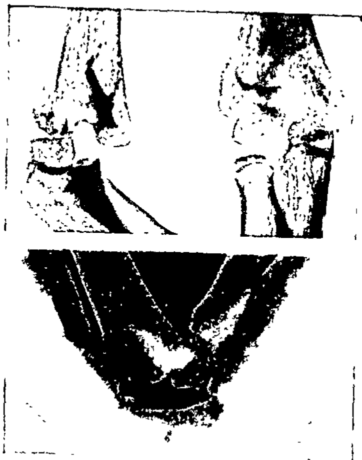


FIG. 511. (*Top*) Intercondylar fracture, with the capitellar portion broken off and displaced posteriorly. (*Bottom*) Showing the fracture reduced and fixed by a posterior plaster splint in acute flexion.

Watson-Jones[32] states that he has had good results in these cases by reduction and immobilization in the fully extended position. Traction is made on the fully *extended* arm, lateral displacement is corrected, and the fragments are engaged by cross pressure. A plaster molded splint may be applied in full extension (Fig. 555). The arm is elevated until swelling subsides and then is carried at the side.

Manipulation of Fractures of the Trochlear Side Alone

This is an adult type of fracture resulting from a fall on the proximal end of the ulna. The trochlear fragment and the ulna move proximally (Fig. 541). The pull of the flexor-pronator muscles attached to the internal epicondyle also rotates the fragment. There is loss of the carrying angle. Reduction is attempted by traction in hyperextension with abduction of the forearm on the humerus, followed by presure on the fragment and flexion of the forearm.

If reduction is accomplished, a plaster splint 4 or 6 in. wide is applied from the axilla down the inner side of the arm, beneath the elbow and up the outer side of the arm to the deltoid. It is molded snugly to the lateral contours of the lower end of the humerus. A second splint is applied from the axillary fold down the arm, over the point of the elbow and down the ulnar side of the *forearm* to the knuckles. A snug flannel bandage must be applied from the knuckles to the deltoid.

culation. The splints should be loosened without hesitation if the edema of the hand increases, if the hand becomes cold or cyanotic, or if the patient complains of pain in the forearm or paresthesias in the hand. If no change occurs in 10 or 15 minutes, the splints should be removed and the patient should be hospitalized.

Exercise of the hand may begin at once. Roentgenograms are required immediately after application of the immobilizing dressing and again 1 week later. If the position changes during this period, it still can be corrected. Additional films are made from time to time as indicated.

As the swelling subsides, the splints become loose. These should be tightened with bandage and adhesive when necessary.

After 1 to 2 weeks, an unpadded cast may be applied from the knuckles to the axilla, and the whole extremity may be exercised actively and used in daily tasks. After removal of the cast in 2 to 4 additional weeks, active use is continued. No physiotherapy need be used, or, at most, a daily warm bath and gentle massage. Any attempt to increase the range of motion by manipulation, stretching and so forth is prohibited, since continued trauma to the muscles may produce an ossifying myositis. Active use is all that is needed.

EARLY COMPLICATIONS OF FRACTURES ABOUT THE ELBOW

1. Compound Fracture

When a fracture follows direct violence with lacerations of skin and muscle or when a bone end protrudes through the skin, an emergency exists. The extremity must be splinted in the position in which it is found, without any attempt to reduce the fracture or to draw the protruding bone back into the wound. A sterile dressing must be applied, and tetanus and gas gangrene antitoxins administered. The patient is transported to a hospital for immediate operation, consisting of thorough débridement of the wound, reduction of the fracture and immobilization by the most suitable method.

2. Swelling and Bleb Formation

Following severe injuries, the elbow swells, and blebs form on the skin; this is due to hemorrhage and edema. When the tension threatens the arterial blood supply, as evidenced by a diminished radial pulse, or impairs the venous return, as evidenced by cyanosis and edema of the hand, immediate hospitalization is required. In the milder stages, reduction of the fracture and vertical suspension of the arm may diminish the tension and improve the circulation. In the more advanced forms, immediate incision of the bicipital fascia is necessary.

This complication may be prevented largely by the use of an elastic or a flannel bandage, elevation and the use of ice bags both before and after reduction until the acute reaction to trauma subsides. Blebs must be opened, painted with a mild antiseptic and covered with a sterile dressing.

3. Pressure on the Brachial Artery

Absence or diminution of the radial pulse indicates occlusion of the brachial artery; a rupture rarely occurs. In the absence of extreme tissue tension, this indicates direct pressure on the vessel by bone (Fig. 529) or spasm following contusion. Immediate hospitalization for operation is urgent.



FIG. 516. (*Left*) Separation of capitellar epiphysis and fracture of a portion of the adjacent diaphysis, with 90° rotation of the capitellum. The gravity of the lesion was not realized, and closed reduction failed; open reduction was not performed. (*Right*) One month later, the capitellum and its attached diaphysis lie widely displaced laterally. There is calcification along the periosteum stripped from the lateral surface. Range of motion is 15°. The prognosis is severely limited motion and progressive deformity. Operation may be advisable later.

must be taken to move the radius and the ulna medially to get accurate position.

Manipulation of Fractures of the Outer Epicondyle

This rare fracture follows direct violence or avulsion of the radial collateral ligament. Considerable displacement rarely occurs, but, when it does, it may be corrected by direct pressure with the forearm fully flexed and fully supinated. Immobilization in full supination is continued for 3 or 4 weeks. Open operation occasionally is necessary.[27]

Manipulation of Y, T and Comminuted Fractures

Formal reduction and immobilization usually fail in these injuries, and traction and suspension are required.

Treatment of Epiphyseal Separations at the Lower End of the Humerus

Simple epiphyseal separation without diaphyseal fracture is not common. When it does occur, it is treated in the same way as the equivalent fracture (pp. 700, 701).

Early Choice of Treatment for Fractures of the Humerus at the Elbow

Although many fractures in the region of the elbow can be reduced and treated safely in ambulatory patients, there are many others that, by reason of comminution, displacement or complications, such as nerve or vascular injuries or swelling, cannot be treated satisfactorily without hospitalization and traction. It is essential to recognize these latter at an early stage of treatment and not to attempt prolonged or repeated reductions by manipulation. Traction and suspension are the safest methods of handling some of the more severe and complicated injuries.

Treatment After Reduction

After immobilization, the part must be elevated and kept at rest until the swelling subsides. The patient should be examined within 6 or 8 hours after reduction to note any difficulty in cir-

and treatment of the vascular complications described under the headings 2, 3 and 4. Regular re-examination of the injured arm at intervals of a few hours during the first few days after injury is necessary after all severe elbow injuries. A suspicion of trouble makes hospitalization mandatory

Early Signs and Symptoms. The early signs of ischemia may appear in from 4 to 6 hours after the injury or the reduction; there is a delayed onset in rare cases. The patient usually complains of burning pain in the hand and the forearm, accompanied by tingling and numbness of the hand and the fingers. There may be a paralysis of the flexor muscles and immobility of the fingers within a few hours. The muscles become tense and indurated, and any attempt to extend the fingers causes intense pain. The hand may appear pallid or cyanotic in the first few hours, and the radial pulse may diminish or disappear. These are the most important early symptoms.

After 2 days or so, pain and signs of circulatory obstruction decrease, and later the typical contracture appears, accompanied by atrophy of the skin, the hand muscles and the fingers, curvature of the nails and sensitivity to cold.

Treatment of Early Cases. Patients first seen during the acute phase require immediate hospitalization and operation to relieve the circulatory obstruction. The obstruction may be due to external pressure, spasm or thrombus formation. Emergency operation may be required. An instance of successful removal of a thrombus from the brachial artery has been reported [4]

Patients first seen after the acute phase and before dense contracture appears should have the hand splinted in slight hyperextension with felt-padded molded-plaster splints. The extremity must be elevated to abolish edema, then given gentle massage and finger and wrist exercises daily to preserve as much of the muscle function as possible and to maintain flexibility.

Treatment of Late Cases. Treatment is directed toward overcoming the contracture by continuous traction. Operation may be needed to lengthen tendons and free incarcerated nerves.

6. Nerve Injuries

The median, the ulnar and the radial nerves may be involved in elbow injuries.

The radial (musculospiral) nerve at the elbow lies on the brachialis anticus muscle, anterior to the external condyle, and lower, anterior to the head of the radius. It may be involved in compound and simple fractures, especially those of the external condyle, either at the time of the original injury or later by fibrosis. Involvement is manifested by weakness or paralysis of the extensors of the hand, the thumb and the fingers, called wrist drop. Hypesthesia may be present over the dorsum of the first and the second metacarpals.

The ulnar nerve lies posteriorly between the internal condyle and the olecranon. It is involved frequently in flexion supracondylar fractures, epiphyseal separations and fractures of the internal condyle. Sensory disturbances in the fifth finger, the contiguous half of the fourth finger and the ulnar side of the hand and the wrist, vascular disturbances in these areas and paralysis of the muscles of the hypothenar eminence, the interossei, the inner two lumbricales and

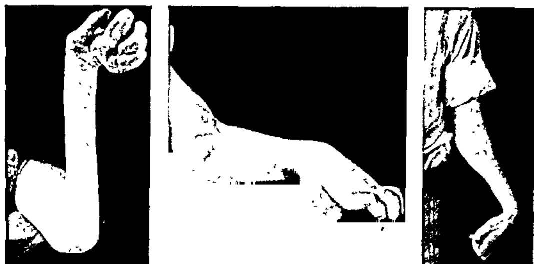


Fig. 547. Volkmann's ischemic contracture. (Meyerding, Henry W., and Krusen, Frank H.: Ann. Surg. 110:419)

4. Impairment of Circulation Due to Acute Flexion After Reduction or to Tight Dressings

Absence of the radial pulse or cyanosis of the hand after acute flexion requires that it be discontinued. The arm must be splinted in a position that permits adequate circulation, even if the fragments slip; or the arm must be suspended. This holds true for tight dressings as well. In the face of circulatory impairment, the splints must be loosened and the effect on the fragments disregarded.

5. Volkmann's Ischemic Contracture (Fig. 547)

This is one of the most serious complications of fractures about the elbow.

Etiology and Pathology. Interference with the circulation in the forearm by extreme tissue tension as the result of hemorrhage and edema, by rupture of the brachial artery with formation of a large hematoma, by direct bony pressure on the brachial artery or by constriction due to tight dressings or a tight cast may lead to a characteristic sequence terminating in the contracture.

The flexor muscles are affected most often. After a period of ischemia, the muscles become indurated and tense. They have a dark bluish color and show extravasation of blood and serum. Leukocytic infiltration and degeneration of the muscle fibers appear. After a few days, organization begins, and fibrous tissue replaces the muscle fibers. The muscles become hard fibrous masses that adhere to the surrounding structures. Nerves, especially the ulnar and the median, are affected primarily by the ischemia[10] or they may become constricted in the fibrous mass, and degeneration follows.

As the fibrous tissue contracts, the muscles shrink and harden, and the typical deformity appears; the wrist becomes flexed, the knuckle joints become hyperextended and the interphalangeal joints become flexed. The end stage varies with the severity of the original ischemia.

Prevention. Ischemic contracture may be prevented by early diagnosis

bone block, and joint motion otherwise is painless. Examination discloses rigidity of the biceps on any attempt to increase extension. Forcible manipulations increase the spasm. Active use, occupational therapy and gentle massage will relieve the condition, but only over a considerable period of time.

Joint fibrosis occurs in some patients. Limitation of motion is due to organization of a hematoma about the joint capsule. The treatment is similar to that for muscle spasm.

Myositis ossificans (Fig. 518), ossifying hematoma and excessive callus formation are complications seen occasionally after severe injuries in childhood. Occasionally, roentgen examination discloses calcifications about the joint. Anteriorly, the mass seems to lie in the brachialis anticus, posteriorly, it follows the periosteal line. Stripping of periosteum with displacement of bone-forming cells may account for the condition. It is especially prone to occur when elbows are manipulated forcibly, "pump handled," to increase the range of motion.

The condition may be prevented by prohibiting forcible passive movements of the joint and by advising only such active use as is painless. When present, the condition is treated only by prolonged immobilization in an unpadded cast and active use. Physiotherapy and passive movements aggravate it. After from 2 to 4 months, much of the bone may be reabsorbed. Operation must not be performed for this condition until a long interval has elapsed, that is, from 3 to 5 years.

Bone Block (Fig 518). Failure to recognize or reduce displacement may result in bony obstruction to motion. After low transcondylar fractures and intercondylar fractures, callus formation in the fossae may have the same effect. In children, the ultimate prognosis may be good nevertheless. As growth occurs, the fracture site shifts away from the joint. In time, the range of motion may become normal, even though the early roentgen appearance and immediate function may look very discouraging. The reparative power in childhood often is amazing.

When the fracture is intra-articular, loose fragments may limit motion and require removal. This is apt to occur in capitellar fractures, and in these also the whole capitellum may rotate and prevent union and block motion.

Deformity

Residual deformities are associated with changes in the carrying angle. Failure to recognize or to reduce the sidewise and rotary displacements is the common cause in supracondylar fractures (Figs 539, 511, 519).

Intercondylar, T and Y fractures have a poor prognosis in this respect. Unless a reasonably good alignment can be secured by closed methods, open operation should be performed.

Simple epiphyseal separation occurs infrequently and has a good prognosis. Fracture of the epiphysis for the capitellum or the trochlea or extension of a fracture line from above into the epiphysis has an uncertain prognosis. When the epiphyseal cartilage is injured, growth may be arrested. If the capitellum fails to grow, the forearm later may deviate outward. If the trochlear area is injured, the forearm later may deviate inward. No treatment affects the condition except osteotomy of the shaft of the humerus; for obvious reasons, it is best to defer operation until growth is complete. The possibility of growth disturbances should be explained to the parents.

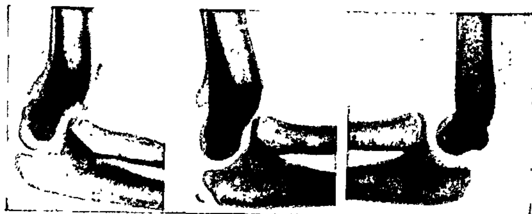


FIG. 548 Unreduced supracondylar fracture. Posterior displacement of the distal portion, with practically no sidewise displacement. (*Left*) Two months after injury much callus, marked deformity and myositis ossificans anteriorly. (Frequently, the area of myositis ossificans is much larger.) Motion greatly limited (*Center*) Three months later: absorption of bone and callus has occurred, the fractured area is smoother, the myositis ossificans is subsiding, and the range of motion has increased The prognosis is fairly good (*Right*) Normal side for comparison

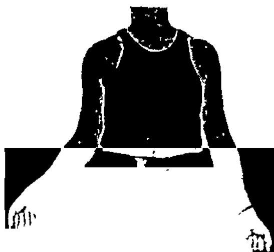


FIG. 549. The right arm shows an increased carrying angle due to incomplete reduction of a supracondylar fracture.

the short flexor of the thumb, are the signs of ulnar nerve injury. Adduction of the hand may be weakened There is constant weakness of the fifth and the fourth fingers and inability to adduct the thumb, which is to be distinguished from opposition supplied by the median. Later, atrophy may occur of the muscles involved, and of the skin and the nails in the sensory area.

The median nerve lies just medial to the brachial artery and passes beneath the bicipital fascia with the vessel It may be damaged whenever the artery is compressed by a hematoma or by forward projection of the shaft of the humerus. Weakness in flexing the fingers and inability to flex the thumb are the motor signs. Paresthesia or numbness in the radial half of the palm, in the ulnar side of the thumb, in the index finger, in the middle finger and the radial side of the fourth finger is the sensory sign.

LATE COMPLICATIONS OF FRACTURES ABOUT THE ELBOW

Limitation of Motion

Persistent muscle spasm may be a complication. After removal of the splint, the patient may be unable to extend the elbow beyond a right angle. Roentgen examination shows no

which are torn away when the lateral ligaments do not give. The brachialis anticus muscle and the triceps are injured also.

DIAGNOSIS

The patient may hold his arm extended or flexed partly. The anteroposterior diameter of the elbow is increased greatly, the antecubital space bulges, and, seen from in front, the forearm looks short. Swelling increases rapidly, but rarely to the point that the epicondyles and the olecranon cannot be defined and compared. With the forearm flexed, the olecranon lies far behind its normal situation, and the forearm appears shortened when compared with the opposite side. The normal relationship of olecranon to epicondyles is maintained in supracondylar fractures. Motion of the joint is much less than normal and very painful when dislocation is present. Roentgen examination should precede reduction; complicating fractures are the rule rather than the exception (Fig. 550).

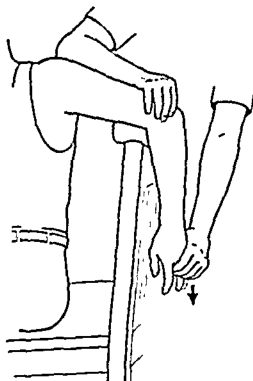


FIG. 551 Reduction of posterior dislocation of the elbow. After allowing the forearm to hang until relaxed, the surgeon makes traction as indicated. (Lavine, L. S.: J. Bone & Joint Surg 35A:786)

TREATMENT

Starkloff[28] has described a simple method of reducing uncomplicated dislocations without anesthesia. The patient is given a suitable dose of morphine, preferably intravenously, and placed supine on a table with the affected arm hanging free from the table. A bag is attached to the wrist with a gauze bandage. Traction is applied by adding from 5 to 10 pounds of weight to the bag, depending upon the age and the muscular development of the patient. This causes no pain. After 15 to 20 minutes of traction, gentle forward pressure is made on the protruding olecranon, and the dislocation is reduced without pain,

Lavine[14] has described another simple method. He places padding over the back of the chair on which the patient sits and then hangs the arm over the back of the chair (Fig. 551). The patient is assured that there will be little or no discomfort, and he is allowed to rest (psychotherapeutic muscle relaxation) until the arm relaxes. The surgeon places one hand over the upper arm and pulls down on the patient's hand with the other. Lavine states that usually the dislocation reduces with ease. No anesthetic is required. Postreduction treatment is given as described below.

Anesthesia. General anesthesia (ether, Vinethene, nitrous oxide, or intravenous) is preferred when an anesthetic is needed. When general anes-

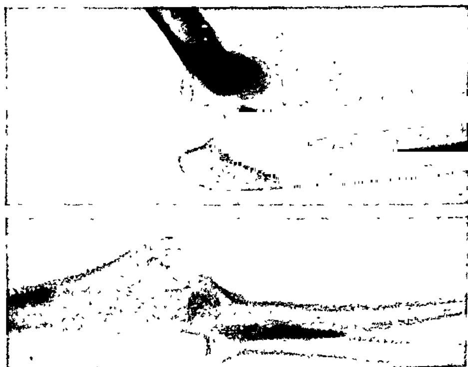


Fig. 550 Posterior and lateral dislocation at the elbow in a 7-year-old child. (*Top*) Posterior dislocation and separation of the medial epicondylar epiphysis with backward displacement. (*Bottom*) Lateral dislocation. The medial epicondylar epiphysis is seen faintly behind the medial condyle.

The residual changes in the carrying angle after supracondylar and intercondylar fractures may be disregarded if they are moderate in degree. Marked deformities can be corrected by osteotomy.

Late Nerve Involvement

This occurs occasionally after fractures about the medial condyle and the trochlear area. Callus or fibrous tissue may compress the ulnar nerve. Neurolysis and anterior transplantation of the nerve may be necessary. Similar late involvement of the radial nerve also may occur.

POSTERIOR DISLOCATIONS AT THE ELBOW

Etiology and Anatomy

The capsule of the elbow joint is loose and thin anteriorly and posteriorly; at the sides, the capsule is reinforced by the lateral ligaments. The ulnar articulation is the strong point; there is a close fit of the coronoid and the olecranon on the trochlear hinge, and the wide flange of the trochlea on the medial side bears against the transversely convex olecranon. When the normal range of extension is exceeded, the capsule tears, and posterior dislocation tends to occur. During a fall that hyperextends or abducts the forearm, the forward thrust of the humerus completes the dislocation.

The radius is bound to the ulna by the strong orbicular ligament and the interosseous membrane; the two bones dislocate usually as a unit.

The coronoid process, the head of the radius and the lateral ligaments resist the dislocation. Most of the posterior dislocations are complicated by fracture of the coronoid process, the head of the radius or the epicondyles,

condyles, and prominence of the head of the radius on the outer side and of the internal epicondyle on the inner side help to make the diagnosis.

Manipulation

With adequate anesthesia, pressure is made on the outer side of the radius and on the inner side of the humerus, and the lateral dislocation is converted into a posterior dislocation. Further reduction is accomplished as for posterior dislocation (p. 717).

MEDIAL DISLOCATIONS AT THE ELBOW

Medial dislocation occurs very rarely. The diagnosis and the treatment are analogous to those described for lateral dislocations.

ANTERIOR DISLOCATIONS AT THE ELBOW

Anterior dislocation at the elbow without fracture of the upper ulna is extremely rare. The elbow is carried in extension, and the olecranon is missing from its position between the condyles. The forearm lies anterior to the arm.

Treatment

Reduction is effected by strong traction in full extension. After the pull has been maintained for a few minutes, the lower humerus is held fixed, and the upper forearm is pressed backward.

Postreduction treatment is the same as for the other dislocations (p 718)

DISLOCATIONS OF THE RADIUS AT THE ELBOW

Dislocation of the proximal end of the radius frequently accompanies fractures of the shaft or the proximal end of the ulna. It rarely occurs alone. Rupture of the annular ligament precedes the dislocation. When it occurs without ulnar fracture, the radial head may go forward, outward or backward, and the unusual prominence of the upper end of the radius should lead to the diagnosis. Rotation of the forearm helps to verify the position of the head. The other signs are those present in any elbow injury. When the head of the radius is dislocated, the entire forearm should be examined for other fractures Fig. 552).

Treatment

Reduction may be effected by traction on the ulnar-flexed hand with the forearm extended and pronated or supinated. Direct pressure on the proximal end then is applied. The position may be maintained best by flexing the fully supinated forearm. A posterior plaster splint is applied after testing the stability of reduction by gentle rotation.

Recurrence of the displacement may occur due to infolding of the orbicular ligament, and operation for repair or reconstruction of the annular ligament may be required.

SUBLUXATION OF THE HEAD OF THE RADIUS: "PULLED ELBOW"

Peculiar to young children, usually under 8 years of age, is the injury called "pulled elbow." It is a subluxation of the head of the radius that follows sudden pull on a child's extended arm, perhaps to keep him from falling. The child yelps, dangles the arm at the side and refuses to move it. He flinches from examination. Typical history, posture and tenderness over the radial head make the diagnosis. The extremity looks normal; roentgen examination is negative.

thesia is contraindicated, brachial plexus block (p. 16) or local infiltration may be used. The space between the olecranon and the humerus is infiltrated with from 10 to 15 cc. of 2 per cent procaine hydrochloride, and the tissues about the projecting end of the humerus are infiltrated with an equal amount of solution. After 15 minutes, manipulation may be started.

Manipulation. The patient is placed on the table as for reduction of a fracture of the humerus. After any lateral subluxation has been reduced, traction is made on the forearm in complete extension to bring the coronoid process of the ulna below the trochlear portion of the humerus. After a few minutes, the shaft of the humerus is pressed toward the table, and additional upward traction is made on the hand. With a gentle rocking motion, the bones disengage, the forearm comes forward, and a distinct snap indicates that reduction has occurred. Flexion, extension and rotation are performed so that any obstruction to movement may be found. A well-padded internal right-angled splint and a snug pressure bandage are applied, and the arm is suspended in a sling. Plaster splints (Fig. 535) covered with a snug bandage may be used instead.

Elevation and ice bags for the next 2 or 3 days decrease swelling and pain. As soon as the swelling subsides, an unpadded cast is applied from the knuckles to the axilla (Fig. 536), and full active use is started. When the soft tissues have not been injured severely, 3 weeks of immobilization is enough, but after severe injuries a longer period may be advisable.

When the cast is removed, hot soaks and gentle massage with a mild counterirritant ointment may be helpful. Passive motion or stretching of the joint is prohibited. In the absence of complicating fractures, the prognosis is excellent if active use is started early and continued regularly.

Complications

Extensive injury to the soft tissues, and especially to the brachialis anticus muscle, occurs regularly. Aside from the stiffness, the most troublesome complications may be ossification in the brachialis muscle or elsewhere about the joint. Its management is described on page 715.

Fractures of the head of the radius, the apex of the coronoid process and the medial epicondyle commonly accompany dislocations. The medial epicondyle may remain in the joint space after reduction of the dislocation. It may be brought out by the method described on page 709. Fractures of the condyles, the capitellum and the bones elsewhere in the forearm may occur.

When fractures are present, the dislocation is reduced in the usual way, and the fracture then is manipulated in whatever manner is necessary. The elbow is immobilized in the position that best maintains reduction of the fracture. Unreduced fractures are treated as described under the individual fractures, the reduced dislocation requiring no special additional treatment.

LATERAL DISLOCATIONS AT THE ELBOW

While some lateral displacement frequently accompanies posterior dislocation (Fig. 550), lateral dislocation alone is a rare injury. The sigmoid fossa may lie beneath the capitellum or the external condyle. Broadening of the elbow, change in the relative positions of the olecranon and the epi-

condyles, and prominence of the head of the radius on the outer side and of the internal epicondyle on the inner side help to make the diagnosis.

Manipulation

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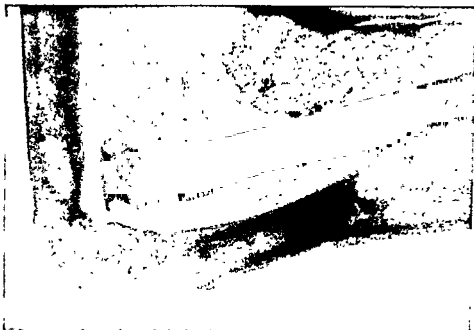


FIG 552. Fracture of the ulna and anterior dislocation of the head of the radius.

TREATMENT

The subluxation can be reduced easily without anesthesia by flexing the forearm a little and rotating gently in supination-pronation while making pressure over the radial head. A click usually is palpable, followed by a quick change from crying to smiling and a willingness to move the arm. No immobilization is necessary,[6] although a sling can be used for a few days if there is apprehension [19]

DISLOCATIONS OF THE RADIUS AT THE ELBOW WITH FRACTURE OF THE ULNA

When the upper ulna is fractured and displaced, the radius takes the thrust. The head of the radius articulates loosely with the capitellum, and it is displaced easily once the orbicular ligament tears.

DIAGNOSIS

Any fracture of the shaft or the proximal portion of the ulna may be complicated by this dislocation. Careful examination of the elbow reveals the deformity of dislocation, and cautious motion may show limitation of supination. Films of these ulnar fractures should include the elbow (FIG. 552).

TREATMENT

The displacement of the ulnar fragments must be overcome first. As the shortening disappears, the displacement of the head of the radius may correct itself, or it may require only direct pressure for reduction. Open reduction may be necessary.[26] Further treatment is similar to that for fracture of the ulna (pp. 728-729) Splints should fit snugly at the elbow, and the checkup roentgenograms should include this joint

FRACTURES OF THE OLECRANON

ANATOMY AND ETIOLOGY

The proximal end of the ulna is

composed of spongy bone, and it is weak in the hollow of the sigmoid fossa. Falls on the forearm and the elbow cause fractures through the fossa. When the fracture is complete and the periosteum and the aponeurotic insertion of the triceps are torn, the triceps draws the olecranon into extension and upward. Clotted blood and torn aponeurosis occupy the space between the fragments, but the separation may be slight because of the large fibrous expansion of the triceps that inserts broadly on the bone. This fibrous insertion rarely is torn completely.

The epiphysis for the olecranon appears between the eighth and the eleventh years, and fuses to the shaft between the seventeenth and the nineteenth years. Epiphyseal separation occurs very rarely, and the cartilage line should not be mistaken for a fracture.

Diagnosis

Discoloration, swelling and *tenderness* over the olecranon process may be present after an injury, even if no separation of the fragments occurs. There is pain on motion of the elbow, especially when the patient attempts to extend the arm against resistance, and an *inability* to extend it fully. Palpation of the subcutaneous border of the ulna will disclose acute tenderness, and irregularity or notching is *present* when displacement occurs. When the fragments separate widely, the deformity is both palpable and visible.

Acute *traumatic* olecranon bursitis may simulate *fracture* without displacement. However, the swelling usually is limited to the bursa, and the tenderness is localized less sharply. Patients who have had previous attacks of bursitis *often* have hard villi in the bursal *floor*; these are acutely

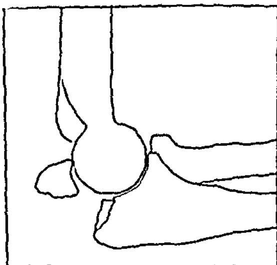


Fig. 553 Fracture of the olecranon. The proximal fragment has been drawn backward and upward by the triceps. This may be overcome largely by full extension of the arm

tender after a hard bump and make the subcutaneous border of the ulna feel irregular. Also, active extension of the elbow against resistance causes no pain. The preliminary examination should include a search for additional fractures.

Treatment

If no separation of the fragments is palpable, an internal right-angled splint is applied from the hand to the axilla (Fig 531). A snug pressure dressing then is applied, and roentgenograms are taken. If these show no separation of the fragments, elevation and ice bags are advised for from 24 to 48 hours. After 3 or 4 days, an unpadded cast (see p. 707) is applied, and the patient returns to his duties. The cast is removed after 4 weeks, and hot soaks and massage are advised for stiffness.

When separation of the fragments is found at the preliminary examination (Fig. 553), the arm is splinted from palm to axilla in full extension with a padded wood splint which is



Fig 551 Anterior wooden splint for fracture of the olecranon when the fragments are displaced.

covered by a pressure dressing (Fig. 554) Roentgenograms then are made.

If the fragments remain separated appreciably with the arm extended fully, operation is the treatment of choice.

If they are in good contact with the arm extended, either the splint is not disturbed or a plaster splint (Fig 555) is applied from palm to axilla. The pressure dressing is reapplied, and elevation and ice bags are advised until the post-traumatic reaction subsides. Active use begins without delay. After 4 to 5 weeks, the splint is removed, and roentgenograms again are made. If definite union is present, an elastic bandage is applied about the extended elbow, and active but limited flexion is started. Hot soaks and massage are prescribed twice daily for stiffness. If there is only meager evidence of union, the splint is reapplied for an additional 2 or 3 weeks Treatment then is continued as described above.

FRACTURES OF THE HEAD AND THE NECK OF THE RADIUS

Anatomy

The head of the radius glides over the capitellum when the forearm is flexed and rotates on the capitellum and the lesser sigmoid fossa of the ulna during pronation-supination. The orbicular ligament holds the *head against the ulnar fossa in rotation* and makes the radius follow the ulna in flexion and extension. The lateral thickened portion of the joint capsule also adds to the stability of the articulation. When the orbicular ligament and the lateral ligaments tear, dislocation of the upper end of *the radius occurs*

The epiphysis for the head appears between 5 and 7 years of age, and fuses to the shaft between 17 and 20 years of age.

Etiology

During a fall on the pronated hand, the head of the radius may be thrust against the capitellum with force sufficient to split the head or impact it on the neck. Falls on the elbow frequently cause fractures of the head and the neck, as do blows on the outer side of the forearm below the elbow.



FIG. 555. Fracture of the olecranon with displacement. Same patient as in Figure 553. An anterior plaster splint is fastened with 2 in. adhesive, a firm flannel bandage completes the dressing.

DISPLACEMENTS (Figs. 556-558)

Splitting or comminution of the head is the common form of fracture The orbicular ligament may retain the fragments in good position, or they may be displaced from beneath the ligament anteriorly, into the muscle mass laterally or into the joint space proximally. The whole head may be broken off and displaced from beneath the orbicular ligament. This is the common displacement after separation of the upper epiphysis of the radius.

After fracture of the neck, the fragments may be angulated with the angle open medially and posteriorly due to the pull of the biceps. With comminution of the neck, the head moves distally and rotates.



FIG 556. Fracture of the head of the radius with negligible displacement.

DIAGNOSIS

After severe elbow injuries, the roentgenologist must show the head and the neck of the radius clearly



FIG. 557. Fracture of the neck of the radius in a 4 year old The center of ossification is very small. The olecranon shows a fracture without displacement. The patient was immobilized in an internal right-angled splint for 25 days; a perfect result was obtained



FIG. 558. Comminuted fracture of the head of the radius There is likely to be limitation of motion after any method of treatment in this type of fracture. If the fragments are removed, the prognosis may be a little better.

Some fractures are identified only after repeated examinations in oblique positions.

The clinical diagnosis of fractures of the head or the neck is based on pain at the site of fracture, swelling over the anterolateral aspect of the elbow joint, and painful and limited rotation and flexion of the forearm There is localized tenderness, which is accentuated by rotation with the thumb pressing on the head of the bone. In occasional cases, on palpating the lateral aspect of the forearm just distal to the external epicondyle, it will be noted that the head does not rotate with the shaft, that crepitus is present, or that there is some deformity on comparison with the opposite side.

In many cases, fracture cannot be identified or excluded except by roentgenograms. Even when a definite diagnosis is made on physical signs, roentgenograms still are urgently necessary to identify displacements.

TREATMENT

Immediately after examination, a snug flannel or elastic bandage is applied about the flexed elbow, the joint is immobilized by an internal right-angled splint extending from the palm to the axilla, and a sling is applied. As an alternative, the flexed elbow is covered with absorbent cotton 1 in. thick, which is bound firmly with gauze or muslin bandage, and a triangular sling then is applied. Roentgen examination follows.

Treatment of Separation of the Upper Epiphysis of the Radius

This occurs between 7 and 15 years

of age. In smaller children, the ossified center of the epiphysis represents only a small part of the large cartilaginous head (Fig. 557). Even when the clinical signs are definite, repeated oblique views of the elbow may be necessary to demonstrate the displaced head.

When displacement is slight or absent, the separation is treated as a fracture in good position. When there is marked tilting of the head, manipulation should be attempted to improve position. Under general anesthesia, the elbow is extended and the forearm is adducted by making lateral pressure on the medial side of the joint. The forearm is rotated so that the most prominent part of the head lies laterally. Strong digital pressure is made on the head to replace it.[12] When the head has slipped from beneath the orbicular ligament into the joint space or into the muscle mass, and if reduction fails, early open operation must be performed. It is preferable to replace rather than excise the separated head.

Choice of Treatment for Fractures

The disk-shaped head fits snugly beneath the orbicular ligament and rotates smoothly. Fracture of the head destroys part of the articular surface, leaves it roughened and distorts the contour of the head. When comminution and displacement are slight, a simple form of treatment produces good results. When the destruction of the head is more extensive, the ultimate result of conservative therapy will be a thickened rough head with great impairment of elbow function and pain. In these cases, the best results are obtained by removal of the fragmented head. Operation should be performed within a week or so of injury, when there is substantial damage or tilting of the head.

Fractures Amenable to Simple Treatment

Certain fractures will heal with little distortion of the articular surfaces and with little change in the size of the head. These are (1) the incomplete fractures of the head; (2) simple splitting of the head without displacement, (3) chip fractures without displacement or with displacement of the chip into the muscle mass, the chip being disregarded unless it produces symptoms later; (4) fractures involving less than one fourth or one third of the articular surface in good position; (5) impacted fractures of the head with slight displacement; and (6) fractures of the neck with no displacement or moderate displacement that does not limit motion In these types, the original dressing may be removed after 3 or 4 days and replaced by an unpadded cast extending from the knuckles to the axilla (p 707), with the forearm held in right-angled flexion and moderate pronation. Full active use begins immediately, and is continued until the cast is removed. The continuous use of a sling is prohibited. After 4 or 5 weeks, the cast is removed. If satisfactory union is demonstrated by palpation and films, full active use is continued. Hot soaks and gentle massage twice daily are prescribed for stiffness and pain, and are continued for 4 to 8 weeks if necessary.

If union is meager, a very light unpadded cast may be reapplied for an additional 2 weeks

Displaced fractures of the neck of the radius may be reducible. With the elbow extended and the forearm supinated, and an assistant exerting strong proximal traction on the arm,

lateral pressure is made on the medial humeral condyle until the carrying angle is reversed, the lateral joint space thus being opened. Direct pressure, anteriorly or posteriorly as indicated, is made on the small fragment to replace it.

Fractures Treated Best by Operation (Fig. 558)

These are (1) extensive comminution of the head or neck; (2) displacement of the head or of its fragments from beneath the orbicular ligament; (3) impaction of the head or angulation at the neck causing marked distortion of the ulnar or the capitellar articulations, and (4) the presence of loose fragments in the joint space. Some unsatisfactory end results have been reported[20] from excision of the radial head, and an effort should be made to procure closed reduction.

These are the fractures that ultimately make the head of the radius an impediment to good function and are rarely affected by manipulation. Early open operation and excision of the head of the bone are the treatment of choice. In doubtful cases, immediate consultation is advisable.

Injection and Mobilization Treatment of Fractures of the Head and the Neck of the Radius

Leriche and Fontaine,[15] because of the poor functional results that usually follow operations for fracture of the head of the radius, have suggested the use of procaine injections and active function rather than operation and immobilization in the treatment of these cases. We have treated many fractures of the head of the radius by this method with excellent functional results. Postlethwait[23] suggests preliminary aspiration of the joint by inserting a needle into the triangle formed by the head of the radius, the lateral epicondyle and the tip of the olecranon, followed by injection of from 5 to 8 cc. of 1 per cent procaine through the same needle. Quigley[21] found that aspiration alone often gave striking relief of pain.

PROGNOSIS

Simple fractures usually have good results, although slight limitation of motion is common. Fractures requiring operation have a less favorable prognosis. The elbow is useful, but some limitation of motion and a little discomfort frequently remain.

MECHANICS OF THE FOREARM

It is perhaps unnecessary to say that the hand articulates with the radius, the radius articulates with the ulna, and the ulna articulates with the humerus. A thrust on the hand is transmitted by this path to the humerus and the shoulder. The radius is bound to the ulna at the upper and the lower articulations by ligaments, and throughout most of its length by the strong interosseous membrane Most of the fibers of the membrane run upward and outward from the ulna to the radius.

When the upper end of the ulna breaks, the head of the radius frequently dislocates upward (Fig 552) When the lower end of the radius breaks, there is a subluxation of the ulna at the inferior radio-ulnar joint. Both are due to the original violence and the added muscular tension

Muscular tension has other effects In supination, the bones of the forearm are well separated. As rotation begins, the space widens slightly, becoming widest halfway between supination and pronation. As pronation is com-



Fig. 559. (*Left*) Internal right angled splint, proper length, padded to maintain the normal concavity on the flexor side Note the angulation of the ulna (angle open toward the flexor surface). (*Center and right*) Dorsal splint added Both are strapped on firmly with 2 in adhesive Note that the splints are wide enough to prevent sidewise pressure on the radius or the ulna, which might cause displacement of the fragments and narrowing of the interosseous space. The dressing is completed with a snug flannel bandage from the knuckles to the axilla and a broad (triangular) sling

pleted, the bones come to lie very close to each other. The flexor-pronators and the extensor-supinators pass down the forearm in a spiral fashion and tend to press the two bones together after fracture. Since a full range of rotation (pronation-supination) depends on the presence of a normal interosseous space, narrowing results in a limitation of pronation

Occasionally, fracture occurs at a level that dissociates muscle action, that is, the supinators act on one fragment while the pronators act on the other.

EXAMINATION FOR FRACTURES OF THE FOREARM

Examination of the injured forearm must be thorough and as painless as possible. The patient is seated on a chair with both forearms resting on a small table, the examiner seats himself on the opposite side. Visible deformity makes the diagnosis obvious, but does not dispense with the need for a complete examination. Swelling, ecchymosis and bleb formation are noted. Careful palpation and comparison of the bony contours will disclose even slight degrees of deformity such as thickening, angulation or irregularity of a shaft. The possibility of multiple fractures of a bone, dislocation of the head of the radius and subluxation at the inferior radio-ulnar joint must be kept in mind. In the absence of deformity, sharply localized wincing tenderness over a bone usually means fracture. Crepitus and preternatural mobility should be sought with extreme caution lest displacement occur. Vascular and nervous disturbances must be recorded.

FRACTURES OF THE SHAFT OF THE ULNA

Anatomy and Etiology

The ulna is thick at its upper end and tapers off toward the lower end. The sharp posterior border is subcutaneous and readily palpable.



FIG 560. Fracture of the shaft of the ulna. A wooden peg has been pressed into the dorsal aspect of the interosseous space and another into the palmar (not shown) to prevent encroachment on the space

Fractures occur most often in the middle and the distal thirds of the bone. Direct violence received in fending off a blow or in holding the elbow out of an automobile is the common cause Compounding is common. The fracture line may be transverse, oblique or comminuted. Fractures in the upper third with overlapping are accompanied by forward dislocation of the head of the radius (Fig. 552). The ulnar fragments angulate with the angle open posteriorly, the proximal fragment being flexed; they also move toward the radius. In fractures of the middle and the lower thirds, the pronator quadratus pulls the lower fragment toward the radius, but overlapping does not occur usually unless there is associated fracture or dislocation of the radius.

TREATMENT

A well-padded internal right-angled splint from palm to axilla, covered by a snug bandage, and a triangular sling provide a good preliminary dressing (Fig. 559). The splint should be broad enough to prevent direct pressure on the ulna, thus avoiding angulation of the fragments. Immediate roentgen examination is required.

If the fragments are in good position, the splint is not disturbed, and elevation of the arm and the application of ice bags are prescribed to control swelling. After from 3 to 5 days, an unpadded cast (p. 707) may be applied from the knuckles to the axilla (Fig. 560). Exercises of the fingers are begun the first day and exercises of the shoulder after the cast is applied. Active use of the arm is begun in a few days. Another roentgen examination is made in 7 to 10 days. The cast is maintained for 5 weeks, unless it becomes loose and requires replacement. At this time, the part is examined for union, and the condition is verified by films. If union is incomplete, another cast is applied for 4 weeks.

If the fragments are not in good position, reduction must be performed without delay. The patient is prepared as for reduction of a fracture of both bones of the forearm (pp. 734-735). General or local anesthesia may be used, for the latter, 15 to 20 cc. of 2 per cent procaine hydrochloride is injected at the fracture site and about the radial dislocation. Powerful steady traction is applied to the hand for about 10 minutes to secure alignment of the fragments. Pressure then is made on the head of the radius to reduce the dislocation. While the traction is continued, anterior and posterior molded plaster splints are applied from the knuckles to the axilla and are secured firmly with gauze bandage and adhesive (Fig. 535) The position of the fragments is verified by films

as soon as the plaster is hard. A triangular sling completes the dressing. After 3 or 4 days, new films are made. If the position still is good, the superficial layers of gauze are removed, and circular plaster bandages are applied to convert the plaster splints into a cast. Treatment continues as for a fracture in good position.

For fractures low in the shaft, the method described by Key and Conwell[13] is useful. The assistant holds the forearm in supination and flexion while the surgeon makes direct pressure with his thumbs and forces both fragments posteriorly until he has converted the deformity into a posterior bowing. Then he presses between the radius and the ulna and forces the two bones apart to restore the normal interosseous space; the posterior bowing is corrected by direct pressure. If the radius is not fractured or dislocated, it may help if traction is made on the forearm with the hand forced to the radial side while the surgeon reduces the posterior bowing.

Failure to secure reduction necessitates operation of the subcutaneous leverage or open types. Compound fracture requires immediate operation.

FRACTURES OF THE SHAFT OF THE RADIUS

Anatomy and Etiology

The upper radius is slender and cylindrical as compared with the large lower end. The proximal four fifths is dense, strong bone, while the distal portion is spongy. The bone curves outward from the bicipital tuberosity down, and the interosseous space is widest about the junction of the middle and the distal thirds. The upper third is well covered by muscle, while the distal portion is covered by tendons and is more easily palpable. This distal portion is slightly concave on the flexor side.

The radius is the movable bone of the forearm and receives the pull of the pronators and the supinators. After fracture, muscle pull determines displacement largely, and muscle tension lengthwise and spirally contributes to overlapping and angulation of the fragments toward the interosseous space. Fractures of the lower portion usually are caused by indirect violence, such as falls on the hand. Fractures of the upper portion result frequently from the direct violence of a blow or compression.

Displacements

The most powerful muscle attached to the proximal portion of the bone is the biceps, acting at the bicipital tuberosity. It flexes and supinates. Normally, the supination of the biceps is opposed by the pronator teres and the pronator quadratus The pronator teres attaches to the radius about one third of the way down the shaft, and the quadratus attaches at the extreme lower end. Therefore, a fracture of the upper third of the bone (Fig. 561) permits the biceps to flex and supinate the proximal fragment, while the pronator teres and the quadratus pronate the lower.

Fractures in the middle third do not exhibit this type of displacement. Both the biceps and the pronator teres are attached to the upper fragment, and they balance each other so that the fragment tends to lie in midposition, while the lower fragment tends to lie in pronation. Encroachment on the interosseous space may be the principal displacement.

In the lower third of the bone, the cross pull is less active, and the displacement is due more often to the

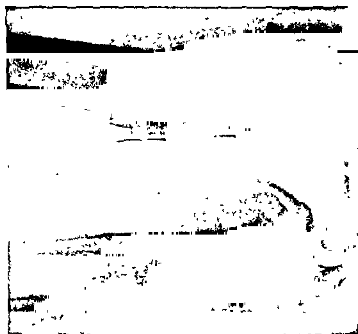


FIG. 561. (*Top*) Fracture of the shaft of the radius at the junction of the middle and the upper thirds The proximal fragment is held flexed by the biceps The distal fragment has moved toward the ulna, and the interosseous space has decreased. (*Bottom*) After reduction.

original violence. The pronator quadratus pulls the lower fragment toward the ulna and the flexor side, and the tension of the extensors of the thumb, which are wrapped round the radius in pronation, also forces the fragments in the same direction. The lower fragment rotates always with the hand.

DIAGNOSIS

Fractures without displacement exhibit only localized tenderness in addition to swelling and pain. Crepitus and pain on rotation may or may not be present.

Fractures with displacement in the lower portion are identified readily by palpable deformity of the shaft, by an inability to supinate, and perhaps by an unusual prominence of the distal end of the ulna resulting from subluxation. It is more difficult to identify fractures in the proximal third because of the large surrounding muscle mass.

TREATMENT

Fractures of the radius in good position are treated in the same manner as those of the ulna (p. 728) Pressure on the outer border of the bone must be avoided lest the fragments be pushed toward the interosseous space. Pressure of the fingers on the wet plaster directly between the bones helps to hold them apart. Fractures in the upper third that appear at all unstable require fixation in the fully supinated position.

Fractures with displacement require reduction without delay unless the fracture line is oblique or comminuted, when hospitalization is preferable. The preparation is as for reduction of both bones of the forearm (pp 734-735). Under general anesthesia or a local injection of 10 to 15 cc. of 2 per cent procaine solution into the fracture site, strong, steady traction is made on the flexed and supinated forearm by way of the thumb and index finger so that the hand is forced toward the ulnar side. After the shortening has been overcome, direct pressure on the distal fragment secures alignment. Fractures in the upper third must be immobilized in supination, while those in the middle and

the lower thirds may be fixed in the midposition.

Simple angulations may be corrected by firm pressure in the interosseous space to overcome the narrowing, combined with direct pressure at the fracture site. It is helpful if an assistant makes traction on the forearm as described above, so that the surgeon may use both hands for manipulation. Extreme caution must be exercised to avoid causing an overlap.

If subluxation has occurred at the inferior radio ulnar joint, it is advisable to press the bones together in the dressing at this point to avoid later difficulty.

Failure to reduce overlapping is common, and operation frequently is necessary.

FRACTURES OF THE SHAFTS OF BOTH BONES OF THE FOREARM

Anatomy and Etiology

The main anatomic points have been covered (pp. 726-729). These fractures result from both falls and direct violence.

Displacements

Direct violence usually breaks both bones at the same level. Indirect violence from a fall on the hand usually breaks the radius at a higher level than the ulna (Fig. 562). The radius takes the thrust and breaks; then the thrust is transmitted to the ulna by the fibers of the interosseous membrane, which attach at a lower level on this bone.

The bones are concave on the flexor and the interosseous surfaces The interosseous space always is narrowed by the action of the pronators and the extensors of the thumb, which draws the fragments together. The lower end of the radius tends to move upward, and the head of the ulna becomes more prominent. When the upper third of the radius is fractured, the displacement is similar to that of fracture of the radius alone: the upper fragment lies in supination; the lower, in pronation. In fractures through the middle and the lower thirds, the upper fragment lies in midposition, and the lower tends to be pronated. Overlapping is common, the lower fragments usually lying posteriorly. Greenstick fractures are common in children;

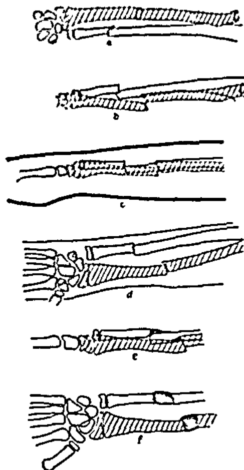


Fig. 562. Fractures of both bones of the forearm. The patient was injured July 19 (a and b) The fractures were reduced July 21 (c and d). Roentgenogram on September 1 (e and f) showed good union. The treatment was immobilization by an unpadded cast from the knuckles to the axilla.



FIG. 563. Fractures of both bones of the forearm with considerable angulation. The point of the angle is toward the flexor side.

the displacement mainly is angulation, usually with the angle open toward the posterior surface.

Diagnosis

The common types of overlapping and greenstick fractures usually are recognized at a glance (Fig. 563). Careful examination for multiple fractures must be made. Fractures in good position may be identified by the localized swelling, by the sharply localized acute tenderness and by some palpable irregularity of contour. Crepitus and mobility should be sought with caution, if at all, to avoid displacing the fragments. Roentgen examination is necessary in all cases for accurate determination of the position of the fragments.

Emergency Care

After the initial examination is completed, the forearm is immobilized from the knuckles to the axilla on a heavily padded internal right-angled splint, the dorsum of the forearm being protected by an additional splint extending from the knuckles to the elbow (Fig. 559). A firm bandage and a triangular sling complete the dressing. Plaster splints also may be used. The patient is instructed to keep the arm elevated and to apply cold in the form of ice bags. Films are made immediately, so that reduction may be performed without delay.

Treatment

Fractures in Good Position

Fractures are in good position if the interosseous space is not narrowed, if no considerable angulation is present, and if from one half to one third of the ends are in stable apposition.

When little or no displacement of the fragments has occurred, the forearm is flexed to a right angle and rotated to the midposition. Molded plaster splints are applied from the knuckles to the axilla, and are bound snugly with bandage and adhesive When the radius is fractured in the upper third, a position of full supination may be satisfactory for maintaining position. In the lower third, moderate pronation may be used for unstable fractures to lessen the tension of the pronators and to prevent displacement. Pressure is made in the interosseous space while the plaster sets. The arm is placed in a triangular sling, and the patient is instructed to keep it elevated and at rest. The fingers and the shoulder are exercised from the beginning. After 4 or 5 days, the superficial layers of bandage are removed, and circular plaster is applied to convert the splints into a plaster cast. Active use is begun, and the sling usually is discarded. Films are made after 1 week and repeated as necessary. In children, from 4 to 6 weeks of immobilization usually is

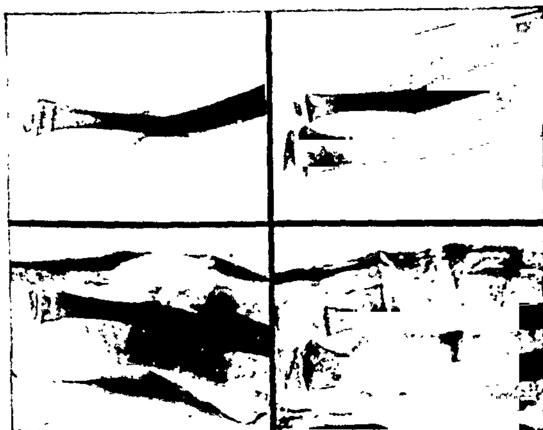


Fig 564. (*Top*) Greenstick fracture of both bones of the forearm (*Bottom*) After reduction Same patient as in Figure 565

adequate. In adults, the cast is removed after 6 weeks, and union is determined by palpation and roentgenography. If union is reasonably solid, no dressing is applied If little callus has formed, an unpadded cast (p. 707) is reapplied for 4 weeks. Union is slow in most of these fractures. Patients who use the arm constantly have a little difficulty with stiffness of the wrist or the elbow, and hot soaks and gentle massage twice daily overcome readily what there is.

Treatment of Fractures with Angulation Only (Fig. 564)

In children, the bones often break incompletely and bend, producing the greenstick type of fracture. After the films are inspected, reduction is performed The assistant makes traction on the patient's hand with the forearm flexed to a right angle. The surgeon grasps the forearm above and below the fracture site with his thumbs pressing into the interosseous space and his fingers flat on the opposite surface. A common error is to grasp the bones so as to press them toward each other; the interosseous space thus is narrowed, and it is very difficult to overcome this later. The angulation is overcorrected sharply, and the bones are permitted to spring back to normal position. The normal concavity of the flexor side must be borne in mind. Molded plaster splints are applied from the knuckles to the axilla. If there has been little soft-tissue injury, circular plaster may be added immediately, pressure being made in the interosseous space while it sets. The patient is treated as for a fracture in good position (p. 732).



FIG. 565 Correction of angulation of a greenstick fracture The point of the angle was toward the flexor surface. The cast was cut on the dorsal surface, and a wedge was removed on the flexor surface. The angulation then was corrected, and the correction was maintained with circular plaster. (See Fig 561)



FIG. 566. (*Left*) Setup for reduction of fractures in the forearm A wide strap is placed about the upper arm: it is padded anteriorly with 2 or 3 thicknesses of felt Plaster splints are applied and fastened with gauze bandage after reduction (*Right*) The wood pegs are being pressed in The surgeon has reversed the position of his right arm for the photograph With the foot on a stool, the knee is used to brace the left hand Circular plaster then is applied, and the procedure is repeated until the plaster is hard.

Another method (Fig 565) may be useful when there is an absence of swelling and the interosseous space is normal No anesthesia usually is necessary. A felt pad is applied over the angulation. Then a snug circular plaster cast is applied from below the axilla to the metacarpophalangeal crease without disturbing the fractures. When it has set, the dorsum of the cast is cut transversely about half an inch proximal to the site of the fractures, and the distal fragments are swung gently into position as the cast is bent enough to correct the angulation The fluoroscope or the roentgenogram is used to verify the reduction. To maintain the reduction, a few turns of plaster of Paris are used to fill in the resultant defect.

Treatment of Fractures with Displacement

Compound fractures require emer-

gency operation. In simple fractures, the films must be inspected for obliquity or comminution. When these occur, reduction must be supplemented by wires or pins transfixing the bones and incorporated in the cast to maintain position. In the presence of considerable soft-tissue injury with very much swelling, reduction is likely to be extremely difficult, and hospitalization is indicated.

Reduction must be performed without delay. Adequate facilities for general or local anesthesia, expert roentgen control, good assistants and a means of preparing and applying plaster rapidly are basic necessities. It is extremely difficult to reduce these fractures and maintain them in position, and, unless the practitioner has both facilities and experience, expert help should be obtained or the patient should be transferred to the hospital.

For reduction, we use a modification of Bohler's method (Fig. 566), employing general or local anesthesia For the latter, each fracture site is infiltrated with 10 cc. of 2 per cent procaine solution, 10 minutes being allowed to elapse before the procedure is begun. The roentgen films are hung within sight of the surgeon. With the patient in the supine position on a table with the injured arm over the side, the forearm is flexed to 90°, and a piece of felt 18 x 8 x 1 cm. is placed in front of the arm just above the elbow. A wide strap is passed over this and fastened to a fixed object beyond the head of the table. Adhesive is wrapped about the thumb and then about the second, the third and the fourth fingers. The assistant then seats himself and makes steady traction on the thumb with one hand and somewhat less traction on the second, the third and the fourth fingers with the other. For fractures in the upper third, the hand is held in supination: for those in the middle and the lower thirds, it is held in midposition. After 5 to 10 minutes, the overlapping and the subluxation at the lower radio-ulnar joint are overcome. While the assistant continues the traction, the surgeon presses into the interosseous space with his thumbs on the flexor surface and his fingers on the extensor surface to force the bones apart into normal relationship The end-to-end apposition of the radial and the ulnar fragments then may be adjusted if necessary.

When reduction is complete and while traction is continued, a molded plaster splint is applied on the extensor surface from the knuckles, over the point of the elbow and up to the axilla, and fastened with a gauze bandage. Another splint is applied on the flexor surface from the flexion crease of the palm to the elbow; this is fastened by another bandage. As soon as the plaster is hard, the traction is discontinued, and the strap, but not the felt, is removed from above the elbow Circular plaster then is applied to make a cast, and the position of the fragments is determined by a film If the position is unsatisfactory, the cast is removed and a new reduction is attempted. The patient then is put to bed with the arm elevated as high as possible. If swelling occurs, the cast may be split between the thumb and the index finger. If it continues after a few hours, the whole cast may be split along its extensor side and held in place with a gauze bandage.

When the fracture lines are oblique or comminuted, or when marked dislocation of the lower radio-ulnar joint

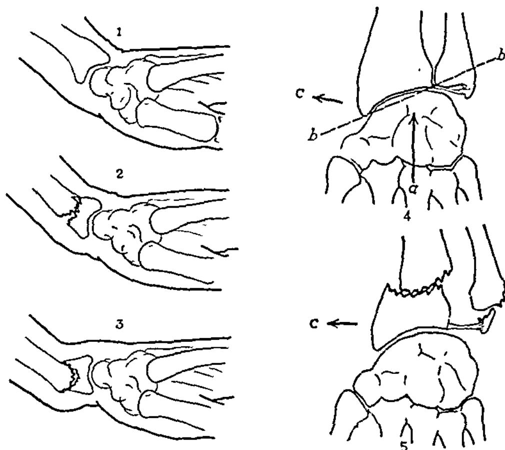


FIG. 567. Mechanism of dorsiflexion suprastyloid fracture (1) The patient falls forward on the dorsiflexed hand. (2) The radius breaks in its weak, spongy portion proximal to the articular surface. (3) The hand is fixed on the ground. If the force is great, the shaft of the radius is driven downward and into the distal fragment, producing the typical deformity. (4) Seen from in front, the plane of the articular surface (b) lies at an oblique angle to the long axis of the bone. When the hand is thrust proximally in direction (a) against the oblique surface, there is a component of the resulting force in direction (c) which carries the distal fragment toward the radial side (5). The ulnar styloid is torn away if the triangular ligament does not rupture. The radioulnar joint may be disrupted entirely. (See Fig 575)

has occurred, the position of the fragments may be maintained by transfixing the ulna above and the radius and the ulna below by stainless-steel wires, these being incorporated in the cast. Failure to reduce these fractures or to maintain reduction frequently makes operation necessary.

The after-care of these patients is described under fractures in good position (p. 732). The cast should remain for about 6 weeks for fractures in the middle third and from 4 to 5 weeks when they are in the lower or the upper end. A roentgen examination should be made after the first week. Films are made immediately after removing the cast, a light cast may be applied for an additional 4 weeks or more if union is not solid.

DORSIFLEXION FRACTURE OF THE LOWER END OF THE RADIUS (COLLES' FRACTURE) WITH OR WITHOUT FRACTURE OF THE ULNAR STYLOID

Anatomy

The radius acts as the upward continuation of the hand, and takes the thrust in falls on the hand. The lower end is spongy bone, dense cortex appearing about 1 to 2 cm. from the distal end; the area 1 to 2 cm. from the articular surface is the common site of fracture. The tip of the radial styloid lies about 1 cm. beyond the tip of the ulnar styloid, and the articular surface is seen to lie not at right angles to the long axis but inclined about 25° toward the ulnar side. In the lateral view, the articular surface faces toward the palm rather than straight ahead. The angle with the long axis is about 15° beyond the right angle.

In girls, the epiphysis for the lower end of the radius appears in the sixth to the tenth months of age; in boys, it appears between the twelfth month and the third year. The epiphysis fuses to the shaft between the twenty-first and the twenty-fifth years. The epiphysis for the lower end of the ulna appears in the sixth year and fuses to the shaft between the twentieth and the twenty-fourth years. There may be a separate epiphysis for the ulnar styloid.

Displacement

During a fall forward on the palm of the hand, the body continues to go forward after the palm becomes fixed against the ground, the wrist being forced beyond the normal bony limit of dorsiflexion.[16]

The protruding dorsal outer margin receives the impact, and following fracture the distal fragment thereby is driven proximally and toward the dorsum as well as toward the radial side (Fig. 567). As the distal fragment moves toward the radial side, the tense triangular ligament frequently pulls off the ulnar styloid. Considerable bone compression with loss of bone substance in a wedge shape occurs often. This loss of substance may account for the ease with which deformity recurs after good reduction.[7]

The fractures vary greatly in displacement (Figs. 571, 575 and 577). In children, there may be only very slight buckling of the bone or slight dorsal displacement of the lower epiphysis of the radius There may be marked impaction on the dorsal side or complete overlapping without impaction. Comminution with extension of the fracture lines into the wrist joint and the radio-ulnar joint occurs frequently. Slight subluxation at the radio-ulnar joint is very common; the ulnar styloid becomes more prominent and the hand shifts toward the radial side.

Diagnosis

When dorsal displacement has occurred, the wrist exhibits a typical fork deformity (Fig. 568). Swelling may obscure this. When compared with the normal side, the site of fracture shows thickening, irregularity of contour and acute tenderness, and the radial styloid lies close to the level of the ulnar styloid. There is pain on full flexion of the hand. Tenderness over the ulnar styloid indicates a fracture at that point. There may be additional fractures of the carpal bones.

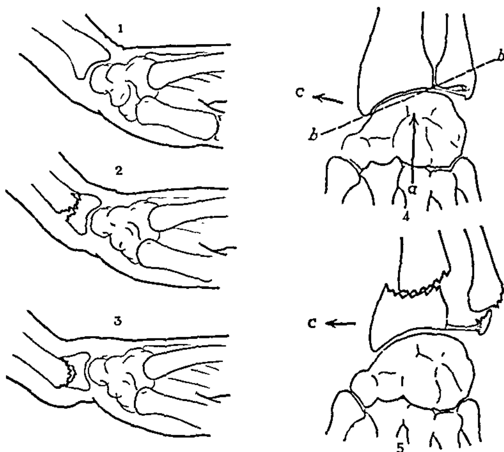


FIG 567. Mechanism of dorsiflexion suprastyloid fracture (1) The patient falls forward on the dorsiflexed hand (2) The radius breaks in its weak, spongy portion proximal to the articular surface. (3) The hand is fixed on the ground. If the force is great, the shaft of the radius is driven downward and into the distal fragment, producing the typical deformity (4) Seen from in front, the plane of the articular surface (b) lies at an oblique angle to the long axis of the bone. When the hand is thrust proximally in direction (a) against the oblique surface, there is a component of the resulting force in direction (c) which carries the distal fragment toward the radial side (5). The ulnar styloid is torn away if the triangular ligament does not rupture. The radioulnar joint may be disrupted entirely. (See Fig. 575)

has occurred, the position of the fragments may be maintained by transfixing the ulna above and the radius and the ulna below by stainless-steel wires, these being incorporated in the cast. Failure to reduce these fractures or to maintain reduction frequently makes operation necessary.

The after-care of these patients is described under fractures in good position (p. 732). The cast should remain for about 6 weeks for fractures in the middle third and from 4 to 5 weeks when they are in the lower or the upper end. A roentgen examination should be made after the first week. Films are made immediately after removing the cast; a light cast may be applied for an additional 4 weeks or more if union is not solid.



FIG 570. Unpadded cast for suprastyloid fracture of the left radius (*Top*) A plaster splint, long enough to reach from the knuckles to 1 in. below the elbow, is made and laid on the dorsal surface. Circular plaster is wrapped on to make the cast Care is taken to round off the edges, and firm pressure is made to mold the plaster in the palm and round the fracture. The cast is trimmed in the palm and round the thumb to allow full flexion of the thumb and the fingers On the dorsum, it projects very slightly over the knuckles. (*Bottom*) Showing the range of motion immediately after the cast was removed. The part was used actively from the beginning.

often is normal. Very early removal of the cast to give physiotherapy is not advised The best form of therapy is active use, and this is performed most safely while the fracture is protected by the cast.

Treatment of Fractures with Displacement

The displacement of the fragments may be estimated accurately from the films. The anteroposterior view shows the shift of the lower fragment to the radial side, the shortening of the bone and the disturbance of the lower radio-ulnar joint Fracture of the ulnar styloid also may be present (Fig. 567). The lateral view shows the rotation of the articular surface toward the dorsum and the degree of impaction of the fragments (Fig. 571). Impaction of spongy bone means crushing and loss of structure. After reduction, an actual gap may be visible at the dorsum, or the radius may remain shortened due to loss of substance after crushing. Every effort must be made to obtain accurate replacement and immobilization in industrial workers. A substantial average residual disability in workmen's compensation cases has been reported [2]

Reduction

Reduction should be performed without undue delay, but it should not be attempted without adequate anesthesia and assistance. Local anesthesia is more satisfactory early and when the fragments are loose, so that

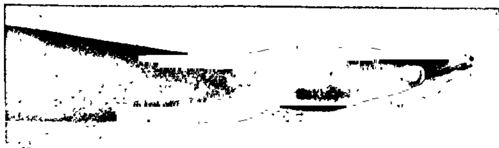


FIG. 568. Typical deformity seen in a dorsiflexion suprastyloid fracture of the lower end of the radius

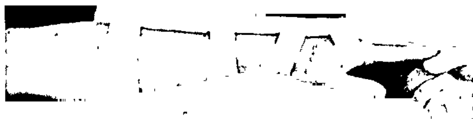


FIG. 569 Dorsal wooden splint from the elbow to the knuckles, the first dressing for fractures about the wrist. The dressing is completed with a firm flannel bandage.

TREATMENT

After the examination is completed, a heavily padded wooden splint is applied to the dorsal surface from the knuckles to the elbow (Fig 569) with the hand in midposition of rotation and flexion. A firm bandage covers both arm and splint, and a wide sling is added. Films are made, the angulation of the articular surface is determined, and reduction is performed when necessary without undue delay

Treatment of Fractures in Good Position

If no displacement has occurred, or if the articular surface still inclines toward the palm and there is no appreciable outward displacement, the original splint may be left undisturbed for 3 or 4 days, during which time the patient keeps the arm elevated and exercises the fingers fully. The splint then is removed and replaced by an unpadded cast (Fig. 570) Normal use of the whole arm and hand may be resumed. Especial care is taken to exercise the fingers through their full range of motion, to pronate and supinate as fully as possible, and to move the shoulder and the elbow through a full range at least 3 times daily. Elderly patients frequently sustain mild injuries about the elbow and the shoulder, and if they are permitted to carry the arm in a sling without exercises, severe disability may follow.

The cast may be removed in about 4 to 6 weeks, and at this time the wrist usually will be found to move freely through an arc of 30° to 45°. After a week or two of hot soaks and energetic use, the range of motion



Fig. 572. Arrangement for reduction of a fracture of the lower end of the radius.

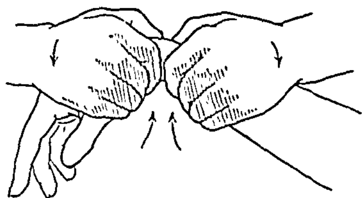


Fig. 573. Method of reducing a dorsiflexion suprastyloid fracture. If the fragments are impacted, this motion may be reversed at first to disengage the fragments.

toward the ulnar side. After 3 or 4 minutes, the surgeon disengages any impaction by direct pressure on the distal fragment. He completes the reduction by grasping the forearm with his two thumbs on the dorsum, one above and one below the fracture site, and with his fingers on the flexor side, and then pressing the distal fragment toward the flexor side (Fig. 573).

When reduction is complete and while traction is continued, a 4- or a 6-in. plaster bandage is rolled out to make a splint long enough to reach from the knuckles to the elbow (Fig. 574). The plaster splint is applied to the dorsum and bound on firmly with gauze bandage. When the arm is very large, and in children, an additional plaster splint may be applied from the palm to the elbow on the flexor surface. The splints are molded firmly in the palm and about the lower end of the radius. In addition, one hand is placed on the flexor surface above the fracture while the heel of the other hand is placed on the dorsum of the distal fragment, and cross pressure is made until the plaster hardens. In the presence of shortening due to comminution or crushing, length may be gained if the assistant forces the hand strongly to the ulnar side while he makes counterpressure with the flat of the hand over the lower ulna. The distal end of the ulna acts as a fulcrum.

The traction is discontinued as soon as the plaster hardens, and a film is made. The position should approximate the normal closely (Fig. 575). If any residual displacement is seen, the plaster is removed, and reduction is repeated immediately. In certain extensively comminuted fractures, ordinary closed reduction and fixation

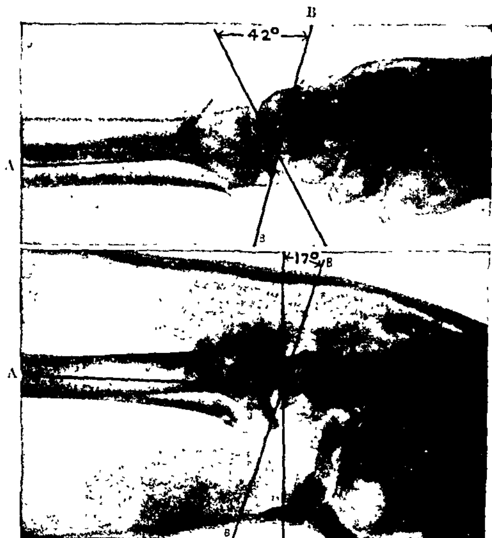


Fig. 571. Lateral view of dorsiflexion fracture. (*Top*) Rotation (42°) and impaction on the dorsal surface are shown (*Bottom*) Reduction was incomplete, the articular surface still lies rotated 17° backward. Note lines (A) bisecting the lower end of the radius lengthwise and (B-B) the normal position of the articular surface.

the anesthetic may reach the bone ends by diffusion through the hematoma. Ordinarily, 15 or 20 cc of 2 per cent procaine solution is injected at the dorsal side of the fracture, and about 3 cc. at the ulnar styloid. When there is impaction, 10 cc. is injected on the dorsal side, 10 cc. on the palmar side and 3 cc. at the ulnar styloid. With extensive impaction, comminution and swelling, Vinethene or intravenous Pentothal Sodium anesthesia sometimes is preferable.

The patient lies on the table with the arm arranged as shown in Figure 572. About 10 minutes after the local anesthetic has been injected, the assistant makes traction on the adhesive-wrapped thumb with one hand and on the second, the third and the fourth fingers with the other, pulling the hand into pronation, flexion and

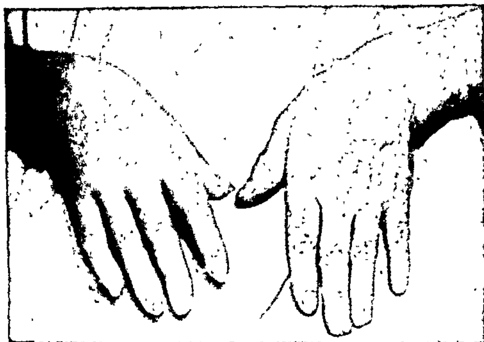


Fig. 576. Hands of a 55-year-old woman who sustained a fracture of the lower end of the right radius 10 weeks before this photograph was taken. Unreduced and poorly immobilized, the right hand became extremely painful, stiff, and duskier and warmer than the left. Duskiness, swelling and loss of the normal skin wrinkles can be seen.

a "pins and needles" feeling. If any circulatory disturbances manifest themselves, the dressing may be loosened by cutting the bandage and applying another on top of it. On the following day, the circulation of the part is examined, and the dressing is tightened or loosened as necessary. The swelling subsides in 3 to 5 days, and the plaster splints may be converted into a cast by removing the superficial layers of gauze, wetting the remaining ones and applying circular plaster from the knuckles to the elbow. In the palm, the plaster must be trimmed to the flexion crease and round the thumb to allow a full range of motion at the metacarpophalangeal joints. On the dorsum, the plaster extends 1 or 2 mm beyond the knuckles. At the elbow, it must be trimmed to allow full motion. The treatment continues as for a fracture in good position (p. 738). Roentgen films are made again in 1 week. If the fragments have moved appreciably, which is quite rare, the displacement may be corrected Additional films are made if indicated.

The cast is removed in 4 to 6 weeks, and the fracture is examined for callus formation; the findings are checked by films. In extensively comminuted fractures, the cast should remain in place for 8 to 12 weeks. The wrist usually moves through half its normal range of motion immediately (see Fig. 570), and, with the aid of daily hot soaks, massage and full use, full function returns frequently in 2 or 3 weeks. Elderly patients with extensively comminuted fractures tend to have late bone absorption with recurrence of deformity, so that immobili-



FIG. 574. Anterior and posterior molded plaster splints for fractures about the wrist. Note that the posterior splint extends just over the knuckles, and that the palmar splint is trimmed to allow full motion of the thumb and the fingers. The splints are bound on snugly with gauze bandage reinforced by adhesive. These splints are converted into a cast by using a wet plaster bandage instead of the gauze.



FIG. 575. (*Left*) Suprastyloid fracture with displacement of the lower fragment of the radius to the radial side (*Center*) Same fracture after reduction. (*Right*) Old unreduced displacement of the lower radial fragment with radio-ulnar subluxation Union in this position requires operation to obtain a satisfactory result.

may fail, and a satisfactory position may be maintained only by external skeletal fixation, that is, a Kirschner wire through the olecranon and another through the first metacarpal or the bases of the second to the fifth metacarpals (Bohler's method) may be incorporated in plaster.[1,7]

When the position is satisfactory, a broad sling is applied, and the patient keeps the arm elevated on pillows to the shoulder level. Flexion and extension of the fingers and pronation and supination of the forearm should be started immediately.

In the presence of swelling, ice bags usually are helpful. The patient is advised to report immediately, by telephone or in person, if the hand becomes cold, blue or numb, or develops

sensory nerve fibers probably also contributes. Procaine injection, 10 cc of 1 per cent solution, into the stellate ganglion often gives relief of pain and eases motion. It can be repeated as necessary. Procaine infiltration of the stiff painful areas about the wrist and the finger joints also may help. Exercises and occupational therapy should be prescribed.

In about half the cases exhibiting fractures of the ulnar styloid, no bony union occurs between the fragments, but symptoms at this point are quite unusual.

Mild pain often persists at the wrist when the fracture line has extended into the articular surface. No special treatment is indicated.

A rare complication is rupture of the extensor pollicis tendon (see p. 524).

EPIPHYSEAL SEPARATION AT THE LOWER END OF THE RADIUS

In children, the lower radial epiphysis may separate after a fall on the palm of the dorsiflexed hand (Fig. 577). Fracture of the ulnar styloid or separation of the lower ulnar epiphysis frequently accompanies displacement of the radial epiphysis.

Epiphyseal separations really are dorsiflexion fractures with the following characteristics: (1) separation without displacement often may not be identified or excluded by the original roentgenogram unless diaphyseal fracture has occurred; (2) when displacement occurs, a mushy crepitus may be elicited; (3) great force may be necessary for reduction; (4) residual displacements frequently are overcome by later bone growth; (5) fractures extending through the epiphysis may be followed by disturbance of bone growth.

The treatment is similar to that for dorsiflexion fracture (p. 738).

PALMAR FLEXION FRACTURE OF THE LOWER END OF THE RADIUS

(Smith's Fracture or Reversed Colles' Fracture)

Etiology

During a fall on the dorsum of the palmar-flexed hand, fracture of the radius occurs about 1 to 2 cm. above the wrist joint. The position of the hand and the tension of the extensor tendons force the distal fragment toward the flexor side (Fig. 578). The fragment moves also to the radial side, and the triangular ligament may be torn, or the ulnar styloid may be fractured. The fracture line frequently is oblique, from behind upward and forward, and there may be extensive comminution.

Diagnosis

The hand is displaced toward the flexor and the radial sides (Fig. 579). This is visible unless the swelling is very great. Palpation discloses the changed relationship of ulnar and radial styloids, and discloses the typical displacement of the distal fragment. Films show the radial displacement and the rotation of the articular surface toward the flexor side.

Treatment

If little or no displacement has occurred, the treatment follows that for dorsiflexion fracture (p. 738).

When there is considerable displacement, reduction is difficult, due to the obliquity and comminution of the fracture line. The reduction method



FIG 577. (*Top*) Epiphyseal separation of the lower end of the radius with dorsal displacement of the distal fragment. (*Bottom*) After reduction.

zation of the fracture site with the hand forced to the ulnar side (as in Fig. 579, *right*) must be maintained until the films show adequate callus.

COMPLICATIONS

Residual disability in industrial workers is common.[2] Swelling and stiffness of the fingers and hand occur often in patients who seek treatment late and in those who do not exercise adequately. An infrequent complication in the older age group is a persistent painful swelling of the hand associated with stiffness of the fingers and often with increased local temperature (Fig. 576). It occurs perhaps even more frequently with the palmar flexion fracture of the lower end of the radius. When the condition has been present for a considerable length of time, definite demineralization of the bones of the hand and the wrist may be seen in the roentgenograms (Sudek's atrophy) It is a complex sympathetic neurovascular disturbance, and it is best described as reflex vascular dystrophy. Extensive soft-tissue injury, severe comminution of the bony fragments, failure to obtain a good reduction, poor immobilization of the fragments, lack of immediate measures to control swelling (pressure dressings, elevation), excessive immobilization of the fingers and failure to exercise the fingers from the beginning may all be inciting factors. Damage to, or persistent irritation of, the

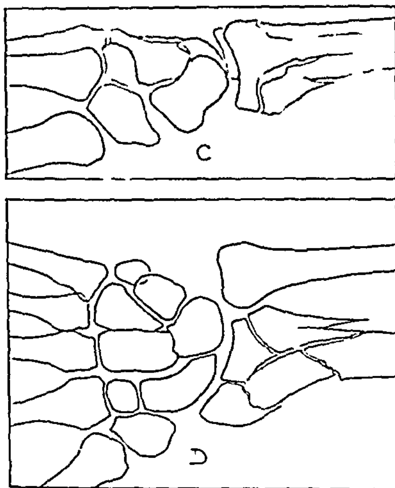


Fig 578 (C and D) Comminuted suprastyloid fracture, flexion type, after reduction (See also A and B.)





Fig. 579. (*Left*) Suprastyloid fracture, palmar flexion type, of the left arm. Note the swelling and the displacement of the hand toward the palmar side. (*Right*) Unpadded cast from the knuckles to the elbow in extreme ulnar deviation, used to maintain the length of the radius after comminution of the bone. This was necessary in the case shown on the left.

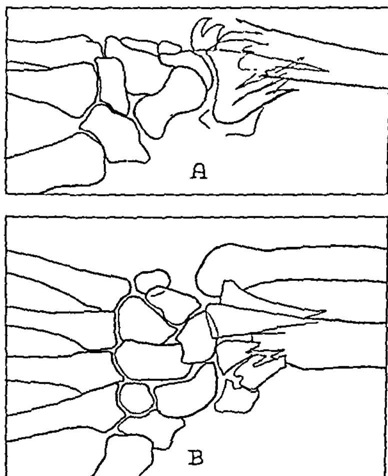


FIG. 578 (A and B) Comminuted suprastyloid fracture, flexion type, before reduction. (See also C and D on next page.)

and the maneuvers follow those for dorsiflexion fracture (p. 739), except that the surgeon's thumbs are placed on the flexor side and the distal fragment is pressed toward the dorsum. Extremely powerful traction toward the ulnar side and toward the dorsum is helpful. Stability of the fragments is obtained best by accurate molding of the plaster about the lower end of the radius and in the space between the thumb and the index finger, moderate dorsiflexion and extreme ulnar deviation of the hand thus being maintained.

The well-known tendency to recurrence of displacement indicates the necessity for weekly roentgenograms for the first 3 weeks. The plaster should remain for from 4 to 6 weeks. Active use and exercises must be continued as described above. Failure to obtain adequate reduction or to maintain position may require operation or Kirschner wire fixation as described on pages 741 to 742. The complications are similar to those occurring after dorsiflexion fracture (p. 744).

FRACTURE OF THE DORSAL LIP OF THE ARTICULAR SURFACE OF THE RADIUS

This fracture occurs infrequently.

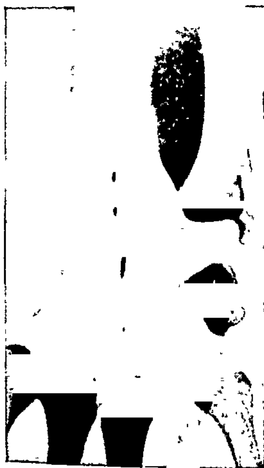


Fig. 582. Isolated fracture of the ulnar styloid

ture may be treated by procaine injection and early mobilization.

DISLOCATION OF THE LOWER RADIO-ULNAR JOINT

When the radius alone is fractured, particularly in the lower third, there is shortening of the bone, and the lower end moves proximally on the ulna. The triangular ligament attaches the rim of the articular surface to the ulnar styloid, and the joint becomes a center of proximal rotation, the radial styloid moving proximally much more than the surface next to the ulna. The hand shifts to the radial side, the lower end of the ulna becomes more prominent (Fig 583), and rotation becomes limited and painful.



Fig. 583. Oblique fracture of the lower end of the radius united with overlapping The prominence is due to dislocation of the head of the ulna toward the flexor surface. Surprisingly little disability occurred during a follow up of more than 10 years

Treatment

The prime element in treatment is reduction of the displacement of the fractured radius. If closed methods fail, open methods must be considered.

The same joint may be disrupted after extensively comminuted or impacted extension or flexion fractures of the lower end of the radius (Figs. 575, *right*, and 578). Good reduction, accurate immobilization and full active use in plaster usually leave the joint asymptomatic. Occasionally, bone absorption at the fracture site shortens the radius and results in slight subluxation. Aside from slight limitation of motion, this disturbance causes little trouble. In old unreduced fractures, the disability and the deformity may be very great. Resection of the lower end of the ulna or partial resection of the ulna and reconstruction of the radius are useful in these cases

Sprains of the joint or self-reduced subluxations are uncommon acute injuries. There is pain on rotating the forearm, local tenderness on the palmar and the dorsal aspects of the joint, and an increased mobility of the distal end of the ulna on the radius as tested by direct pressure. This



FIG. 580 (*Top*) Fracture of the dorsal margin of the articular surface of the radius.

FIG 581 (*Bottom*) Fracture of the palmar margin with subluxation of the carpus. This is similar to the palmar flexion fracture.

The distal fragment may be small or large (Fig. 580), and the fracture may be accompanied by dorsal dislocation of the carpus It is reduced by traction and direct pressure, and the wrist is immobilized in moderate flexion and extreme ulnar deviation.

When the fragment is large, the articular surface does not retain the proximal row of carpal bones, and the carpal dislocation may recur. The complication of recurrent dislocation may require hospitalization.

If the original reduction holds, further treatment is the same as for ordinary suprastyloid fracture Since displacement recurs easily, frequent roentgen examination must be made. After 6 weeks, the cast may be removed.

FRACTURE OF THE PALMAR LIP OF THE ARTICULAR SURFACE OF THE RADIUS

This is a variant of the flexion type of fracture, and it is accompanied sometimes by palmar dislocation of the carpal bones (Fig 581). The treatment is the same as that for dorsal lip fracture, except that traction is made on the dorsiflexed hand in ulnar deviation, and the hand is immobilized in this position.

ISOLATED FRACTURE OF THE ULNAR STYLOID

This is a rather infrequent fracture (Fig. 582). No formal reduction is performed, but the hand may be immobilized for a short time, or the frac-





FIG. 586 (*Left*). Fracture of the body of the navicular. (Ferguson, L. Kraeer: S. Clin. North America 17:1603)

FIG. 587 (*Right*). Fracture of the tuberosity of the navicular. (Ferguson, L. Kraeer: S. Clin. North America 17:1603)

may indicate a rupture of the triangular ligament.

The acute forms are treated by a dressing that presses the lower end of the ulna against the radius This is kept tight for 3 or 4 weeks. If pain and disability recur, a cast may be applied for 4 weeks (Fig. 570), or open operation may be considered.

ANATOMY OF CARPUS AND WRIST

Functionally and anatomically, the inferior radio-ulnar articulation is separate from the radiocarpal articulation (Fig. 584). Ankylosis of the radiocarpal or the wrist joint does not cause necessarily loss of pronation and supination. Despite its mobility, this joint rarely is the site of dislocation.

The carpus and the hand function in 3 distinct units. The first is the proximal C-shaped row of carpal bones, the convex side articulating with the radius and the triangular fibrocartilage. The distal concave side is a socket into which the capitate and the hamate fit and in which they rotate through a considerable arc (Fig. 585). The bones of this row are bound together on the dorsum by a dense ligament and on the palmar side by the anterior annular ligament connecting the pisiform with the tuberosity of the navicular. In the space so formed are enclosed the long flexors of the fingers and the thumb and the median nerve. At the radiocarpal joint, there is a considerable range of dorsiflexion, palmar flexion and sidewise motion. The full range of motions at the wrist requires motion of the distal row of carpal bones on the proximal row.

The second, or thumb, unit consists of the greater multangular and the first metacarpal. These bones move together in a plane at an angle with the plane of the extended hand.

The third unit is made up of the four finger metacarpals and the distal row of carpal bones, to which they are bound strongly. This unit moves on the first unit in the socket-shaped joint described above. It is evident that the extremes of sidewise motion,

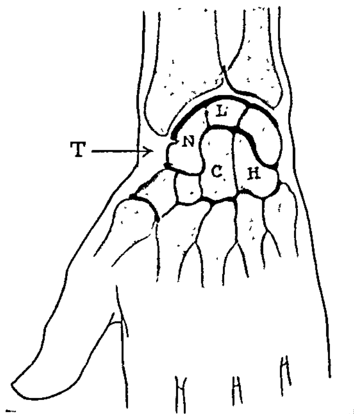


Fig. 581. Coronal section through the carpus showing the synovial spaces (heavy lines): (N) Navicular, (L) lunate, (C) capitate and (H) hamate. Note how snugly the capitate and the hamate fit into the socket made by the proximal row of carpal bones. (T) The tuberosity of the navicular is extra-articular.

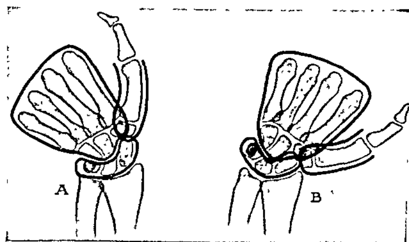


Fig. 585. The motion of the carpal bones. (A) The hand is flexed to the ulnar side and (B) to the radial side. (After Snodgrass, L. E., Am. J. Surg 38.539)

the anatomic snuffbox just distal to the radial styloid. Pressure or percussion in the long axis of the extended thumb causes definite pain at the site of fracture. This pressure causes no increase of pain in simple sprains. Roentgen examination is warranted in patients who exhibit these findings, as well as in those who have persistent pain and stiffness in the radial side of the wrist lasting more than a few days after an injury. Actual sprain at the wrist is an uncommon lesion. Several points concerning the roentgen diagnosis of this fracture deserve emphasis. The routine anteroposterior and lateral views may not demonstrate the fracture. Oblique views should be made in every suspicious case, and the films should be inspected with a hand lens. In addition, if symptoms persist, new films are advisable after 3 or 4 weeks, since a fracture may not be demonstrable until some decalcification has occurred at the fracture line.

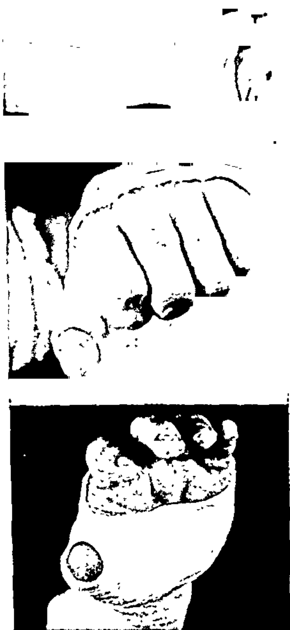


FIG. 589 Cast for immobilizing fractures of the carpal navicular. Note that the cast hugs the dorsal surface of the metacarpal heads when the fingers are flexed; note also the accurate molding to fit the palmar concavity. (Ferguson, L. Kraeer: S. Clin. North America 17: 1603)

TREATMENT

Prolonged and uninterrupted immobilization is required. Operative exposure of a number of fresh fractures[17] has indicated that the fracture often is unstable. An unpadded cast is applied from the knuckles to the elbow, with the hand dorsiflexed slightly and the thumb extended moderately (Fig. 589). A wet 6-in. plaster bandage is rolled out to make a splint of adequate length; it is divided longitudinally. One strip is applied on the dorsum and one on the palmar surface. Very wet circular plaster then is applied, the thumb being included up to its distal joint. The plaster is molded very snugly in the palm and about the lower radius to secure maximum immobility of the wrist joint, and is trimmed in the palm to allow full flexion of the fingers. If the cast is molded well, the metacarpals should not pull away from the dorsum of the

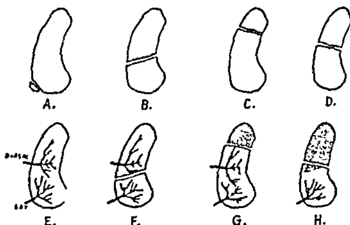


Fig. 588. Types of fracture of the navicular and the blood supply. (A) Fracture of the tuberosity of the navicular, extra-articular; (E) good blood supply, unites without trouble. (B) Fracture through the middle; both fragments receive a good blood supply. (F) Healing usually is good. (C) Fracture through the proximal portion, which becomes avascular (G). Healing is delayed until vessels grow in from the distal fragment. (D) Fracture close to the middle which has destroyed the dorsal blood supply (H) The condition is similar to that in (G). (After Lexer by Schnek)

i.e., ulnar and radial flexion, put a great strain on the sides of the socket; thus, a fracture of the long side of the socket formed by the navicular may occur when the hand is forced sidewise beyond its normal range of motion. A fall or a blow on the radial or the ulnar side of the hand may be a cause of fracture of the navicular. The radial and the ulnar collateral ligaments, which bind the carpus to the radius, are strong and dense at the sides. On the dorsum and on the palmar side are only the rather thin and somewhat lax portions of capsule, reinforced by the overlying tendons. Sidewise dislocation of the wrist is an extremely rare injury.

FRACTURES OF THE CARPAL NAVICULAR (SCAPHOID)

Etiology and Pathology

The navicular may be fractured by falls on the hand, by blows on the wrist and, perhaps, by twisting the wrist. These fractures may be divided into two main groups: (1) fractures of the body of the bone, which are intra-articular and represent a disruption of the proximal carpal arch (Fig. 586); and (2) those of the tuberosity (Fig. 587), which are sprain fractures and are extra-articular (Fig. 588).

The surface of the bone is covered largely by articular cartilage and is avascular except for small dorsal and lateral areas, through which its main vessels enter. If the fracture lies in the proximal portion of the bone, the proximal fragment may lose its blood supply (Fig. 588). In these cases, healing depends on revascularization of the fragment by an ingrowth of vessels from the distal fragment. The loss of blood supply may be identified in the roentgen films after 4 to 6 weeks; the proximal fragment fails to decrease in density as does the distal. Displacement of fragments is very rare.

Diagnosis

The patient complains usually of pain in the wrist, localized in the area just beyond the radial styloid. Grasping with the hand and dorsiflexion of the wrist aggravate the pain. Swelling and acute tenderness are present in

The patient complains of weakness of the hand and pain on motion.

After a year or two, both fragments become dense, and arthritic changes appear, usually indicated by irregular proliferation at the tip of the radial styloid, and still later both fragments undergo necrosis.

Treatment

Within the first 6 to 12 months, prolonged immobilization in an unpadded cast for 4 to 8 months aided by vigorous active use may bring about union. The cast is changed as often as necessary. Open operation should be considered after a reasonable trial of closed treatment.[17]

FRACTURES OF THE DORSUM OF THE CARPUS

Following some severe injuries to the wrist, there is marked swelling associated with acute tenderness over the dorsum of the carpal bones The anteroposterior views show very little. Lateral films frequently show a chip fracture of a carpal bone bordering on the joint betwen the two rows (Fig. 591). This probably is a chip fracture of the lunate, but because the injured bone cannot be identified clearly, it is called a "fracture of the dorsum of the carpus." Other carpal bones may be involved.

Treatment

The original dressing is a wood dorsal splint covered by a snug bandage. As soon as the swelling subsides, an unpadded cast is applied from the knuckles to the elbow (Fig. 570). It remains for 4 weeks, after which time hot soaks and gentle massage clear up any residual stiffness. When this fracture complicates other fractures about the wrist, it requires no treatment beyond that for the major injury.

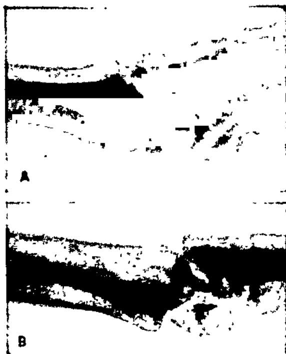


Fig. 592. (A) Perilunar dorsal dislocation of the carpus. (B) Same case showing more clearly that the lunate has remained attached to the radius This may be an intermediate stage in dislocation of the lunate.

DISLOCATIONS OF THE CARPUS

The whole carpus may be dislocated toward the dorsal (Fig 592) or the palmar side. This injury is complicated practically always by a fracture of the dorsal or the palmar lip of the articular surface of the radius and a fracture of the radial or the ulnar styloids The dislocation is reduced by the method described below for dislocation of the lunate. Further treatment as for similar fractures of the radius and the ulna is continued. Immobilization in an unpadded cast for 6 weeks is desirable.

The distal row of carpals may dislocate on the proximal row, either forward or backward; rarely do the metacarpals dislocate on the distal row of



Fig. 590. Old fracture of the carpal navicular. Note the marked decalcification at the fracture line.

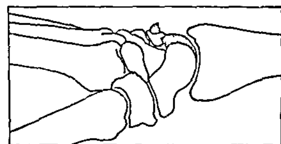


Fig. 591. Fracture of the dorsum of the carpus, with probable involvement of the dorsal lip of the lunate.

cast when the fingers are flexed. This cast provides adequate immobilization and permits active use of the hand; the patient is instructed to use the hand as much as possible. The blood supply remains good, and healing usually is uneventful.

Fractures of the tuberosity require only 4 weeks of immobilization. Fractures of the body require at least 8 weeks.[29] Films are made immediately after the cast is removed. If union is absent or incomplete, a new cast is applied for 4 to 6 weeks. Often union is still incomplete or absent after the second cast is removed. In these cases, the patient is instructed to continue active use because adequate fibrous union probably has occurred. If there is a return of pain, a new cast is applied for 6 to 8 weeks longer. Encasement of the entire hand, including the thumb and the fingers to their tips, in plaster has been advocated for some cases.[5]

OLD UNTREATED FRACTURES OF THE NAVICULAR

Pathology

If the bone has not been immobilized completely, or if immobilization is discontinued too early, the fragments move on each other, and the vessels growing across the fracture line tear. Of course, this happens also in untreated cases. After 6 or 8 weeks, the films show widening of the fracture line and perhaps a decalcification of the distal fragment where it impinges on the proximal, while the proximal fragment remains unchanged or shows a spotty appearance (Fig. 590). The bones of the hand show a uniform decalcification due to disuse.

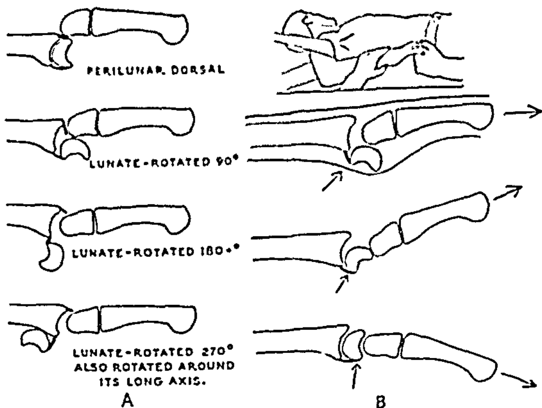


FIG. 591. (A) Dislocation of the lunate The primary lesion probably is a dorsal dislocation of the carpus over the lunate When the carpus springs back, the dorsal radiocarpal ligament is torn, and the lunate is displaced forward. The lunate may rotate on its long axis as well This probably requires open operation. (Redrawn from Böhler.) (B) Reduction of dislocated lunate. The patient is arranged as shown after 20 cc. of 1 per cent procaine solution was injected about the bone An assistant makes powerful traction on the slightly dorsiflexed hand for from 5 to 15 minutes. so as to make room for the lunate. The surgeon grasps the wrist so that his thumb or thumbs press the lunate distally and upward as the dorsiflexion is increased When the pressure is maximal, the hand may be brought into palmar flexion In very recent dislocations, the surgeon may make the traction with one hand and the thumb pressure with the other. (Kaplan, Louis: S. Clin. North America 20:1695)

and swelling, but also a distinct bulge on the anterior aspect of the wrist, marked limitation of palmar flexion, with painful and limited extension and flexion of the fingers. This simulates dorsiflexion fracture. However, in fracture, the tenderness is higher, the distal end of the radius rather than the carpus is the site of the deformity, and marked limitation of finger motion is rare, except in neglected cases.

TREATMENT

Recent dislocations or fracture dislocations are reduced readily (Fig. 591). Replacement of the bone is verified by roentgenograms. Manipulative reduction sometimes is successful even 2 or 3 weeks after the injury. If swelling is not excessive, a cast is applied immediately (Fig. 570); otherwise, a dorsal wood splint and a pressure dressing are used for the first few days. The cast remains for 6 weeks. The pa-



Fig. 593. Dislocation of the lunate. Lateral (A) and anteroposterior (B) views

carpals The dislocations may be complicated by fractures. The treatment is similar to that described for dislocation of the lunate, except for more prolonged immobilization.

DISLOCATIONS OF THE LUNATE

Etiology

Dislocation of the lunate usually is preceded by dorsal dislocation of the carpus, the lunate remaining attached to the radius and the capitate with the surrounding bones lying dorsal to the lunate (Fig. 593). When the dorsal radiocarpal ligament tears, the lunate is pressed down and rotated out of its bed from 90° to 270°, coming to rest on the palmar side of the wrist beneath the flexor tendons and the median nerve. The head of the capitate moves toward the radius. The lunate also may be rotated in the long axis of the extremity (Fig. 594).

Sometimes the proximal portion of the navicular remains attached to the lunate and dislocates with it, the result being a "trans-naviculo-perilunate dislocation." Fractures of the radial and the ulnar styloids also may be present.

Diagnosis

After an injury to the wrist, the patient finds the area swollen and painful, and he has difficulty in flexing and extending the fingers and the wrist. Paresthesias may be felt in the distribution of the median nerve. Examination shows, not only tenderness

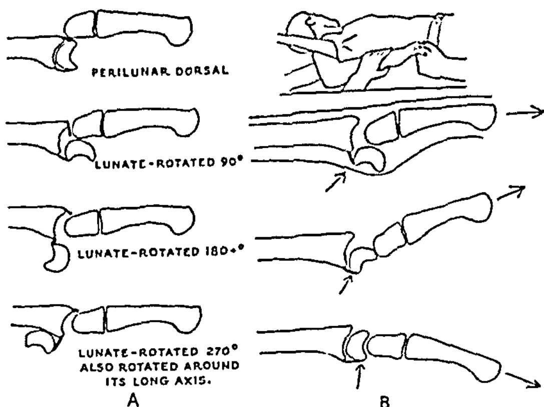


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TREATMENT

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tient begins active use immediately after reduction.

If the dislocation cannot be reduced, open operation is required.

FRACTURES OF THE OTHER CARPAL BONES

Fractures of the other carpal bones are caused by crushing injuries or by forcing the wrist beyond its normal range of motion. The bones being bound together by dense ligaments, substantial displacements are rare. The diagnosis may be suspected from unusual tenderness and swelling, but it can be made only by roentgen films.

A dorsal wood splint and a pressure bandage are applied at first. Later, an unpadded cast is applied for from 4 to 6 weeks. When the greater multangular is fractured, the cast extends to the distal joint of the thumb (Fig. 589).

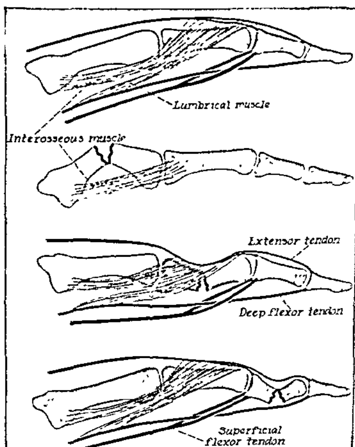


Fig 595 (A) The normal arrangement of the muscles and the tendons (B) Fracture of a metacarpal, the interosseous muscle flexes the distal fragment on the proximal (C) Fracture of a proximal phalanx The interosseous muscles flex the proximal fragment while the lumbricals and the extensor tendon hyperextend the distal. (D) Fracture of a middle phalanx; the bifurcated tendon of the superficial flexor tendon flexes the proximal fragment, and the distal is hyperextended by the extensor tendon.



FIG. 596. Fractures of the first metacarpal. (A) Deformity in Bennett's fracture. (B) Bennett's fracture, actually a fracture dislocation. (C) Transverse fracture of the shaft with no dislocation and (D) after reduction and fixation in the plaster cast. (E) Impacted oblique fracture of the shaft and (F) after removal of the cast, showing position and callus formation.

FRACTURES OF THE METACARPALS

Anatomy. The metacarpals are short and thick; their dorsal surface is straight while the palmar surface is concave, and the weakest portion lies just behind the head. Motion at the metacarpophalangeal joints is mainly in the anteroposterior plane, secondly in limited abduction and adduction from a line between the third and fourth metacarpals and, finally, a little rotation of the fingers on the long axis. These joints are rather loose, the capsules being strongest where they are reinforced by ligamentous thickenings at the sides, which are tense in flexion and relaxed in extension. With the hand closed, the prominence of the knuckle represents the head of the metacarpal, the proximal phalanx lying anteriorly. Flexion is the most powerful motion of the fingers, extension is weaker. The flexor-extensor arrangement is shown in Figure 595.

FRACTURES OF THE FIRST METACARPAL

Bennett's Fracture

The first metacarpal moves freely in two planes due to its saddle-shaped proximal articular surface, which is concave as seen from the side and convex at a right angle to this. A blow on the long axis or on the dorsum of the thumb is the common cause of Bennett's fracture (Fig. 596B). This is really a fracture dislocation, since the small articular fragment on the palmar side remains in normal position, while the base of the metacarpal displaces dorsally over the greater multangular.

Diagnosis. Swelling and acute tenderness occur over the proximal end of the bone, and there is distinct deformity due to the dorsolateral dislocation. Crepitus, marked pain on motion and inability to extend the thumb usually are present. When the fracture is incomplete, localized tenderness and pain on percussion of the

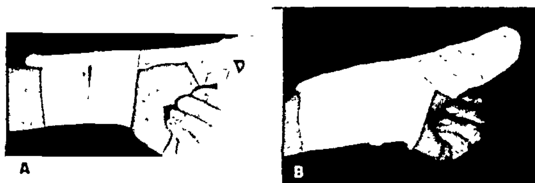


Fig. 597 (A) Well-padded, tapered dorsal wood splint for fracture of first metacarpal secured snugly with adhesive. (B) Firm flannel bandage applied over the splint. The pressure helps to control swelling. (Kaplan, Louis: S. Clin North America 20:1695)

Fig. 598. (A) Shows the deformity of Bennett's fracture and (B) the method of reduction (C and D) Show a finished cast (case shown in Fig. 596C and D). On the dorsum of the hand, the cast should extend to the distal ends of the metacarpals (Kaplan, Louis: S. Clin North America 20:1695)

thumb in the long axis suggest the diagnosis.

Treatment. Full motion of the thumb depends on the preservation of a normal carpometacarpal joint. Abduction-adduction and opposition become limited, and a deformity results if the joint remains distorted.

A wood splint 8 or 9 in. long, 2 in. wide above and 1 in. below, is padded heavily, applied immediately and covered by a snug bandage (Fig. 597). Roentgen films are made and inspected. In the absence of severe comminution, the patient keeps the arm elevated and applies an ice bag for from 24 to 48 hours

If the fragments are in good position, the wood splint may remain in place for 3 or 4 weeks It is better to discard it as soon as the swelling is down, replacing it with an unpadded cast (Fig. 598). This permits active use of the hand without danger of displacing the fragments.

If the usual displacement is present, the fracture remains undisturbed for 3 or 4 days until the swelling subsides. Reduction is performed under local anesthesia, 5 or 6 cc. of 2 per cent procaine solution being injected about the fracture. Adhesive is wrapped about the distal part of the thumb, and an assistant makes traction on the thumb while countertraction is made about the flexed elbow. After a few minutes, the surgeon presses the prominent proximal end of the bone down into place while he brings the distal end outward into full abduction (Fig. 598B). The displacement recurs as soon as the pressure is released.

Application of the Unpadded Cast (Fig. 598). A dripping-wet 3-in. plaster bandage is rolled out to make a splint 8 in. long and ⅛ in. thick. This is divided lengthwise, but slightly obliquely to make 2 tapered splints, each 2 in. wide above and 1 in. wide below. These are applied on the dorsal and the palmar surfaces from the midforearm to the distal joint of the thumb, with the narrower ends lying on the thumb. Circular plaster then is applied from the midforearm down to the distal joint of the thumb, and to the hand as far as the knuckles on the dorsum and as far as the flexion crease in the palm. The surgeon repeats the reduction immediately, but he continues the pressure on the dorsal and the palmar sides with some traction until the plaster hardens. A good deal of pressure may be used without danger of pressure necrosis. Roentgenograms are made to verify reduction. If the position is not satisfactory, the cast is removed, and the manipulation is repeated. Failure to maintain reduction is an indication for continuous traction or internal fixation by an intramedullary wire (Figs. 599–601). An unsightly deformity remains if good position is not obtained.

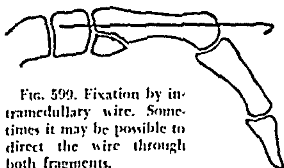


Fig. 599. Fixation by intramedullary wire. Sometimes it may be possible to direct the wire through both fragments.

The patient should be re-examined in 12 to 24 hours. Persistent severe pain at the point of pressure on the dorsum suggests excessive pressure. A part of the cast may be trimmed out at this point and replaced with additional plaster. Active use of the hand begins at once, and no sling is worn.

Another film is made after 7 days. The cast remains for 4 to 6 weeks. Hot soaks and massage, twice daily at home, relieve any residual stiffness quickly.

Intramedullary fixation of these fractures has been found to be useful:[33] with adequate anesthesia, an assistant flexes the first metacarpophalangeal joint to about 110° and makes gentle traction on the axis of the metacarpal while holding it in the abducted and slightly extended position. If the maneuver does not reduce the displacement completely direct pressure is made over the dorsal or the dorsolateral surface of the base of the metacarpal. After the position has been verified by fluoroscopy, a nick is made over the center of the posterior aspect of the metacarpal head, and a medium-sized Kirschner wire is inserted longitudinally so that it traverses the medullary canal. If the wire is started properly, it goes easily and enters the center of the greater multangular. After fluoroscopy for adequate penetration of the multangular (Fig. 599), the wire is cut off 1 cm. distal to the skin, and a dressing and a plaster cast (Fig. 598 C & D) are applied. The plaster and the wire are removed in 4 to 5 weeks.

Impacted and Angulated Fractures Close to the Base (Fig. 596)

It is important to disengage the impaction and to align the fragments.

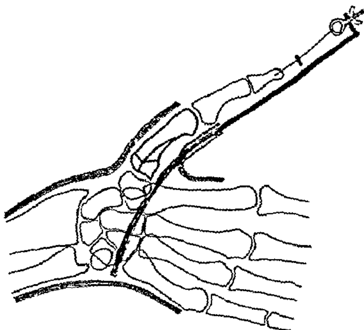


Fig 600. A long bent-wire splint, similar to that shown in Figure 601, is twisted at its end to make a loop, and the loop is bent to a right angle with the length of the wire The splint is incorporated in the wet plaster cast, which is made short in the palm After the plaster is hard, a stainless-steel wire is inserted through the fingertip and attached as shown in Figure 601. The amount of traction is controlled by the wing nut. Angulation, especially of phalangeal fractures, may be corrected by bending the wire at the level of fracture. (Kaplan, Louis S. Clin. North America 20:1695)

The method of reduction is similar to that described above for Bennett's fracture.

Transverse, Oblique and Comminuted Fractures of the Shaft

These fractures often show angulation, with the angle open toward the flexor side. They are treated as are similar fractures of the other metacarpals.

Compound Fractures

If the fracture is seen within 6 to 8 hours, immediate débridement and loose skin closure are performed. The fracture is immobilized in plaster with or without continuous traction as indicated.

Fractures of the Sesamoids

Rarely are the sesamoids at the metacarpophalangeal joint fractured. The treatment is identical with that for fracture of the metacarpal in good position (p. 761), except that the cast extends to the end of the thumb.

Fractures of the Second to the Fifth Metacarpals

These fractures usually result from violence in the long axis of the bone, mostly by the impact of the knuckles of the closed fist against a hard surface. One or more of the metacarpals

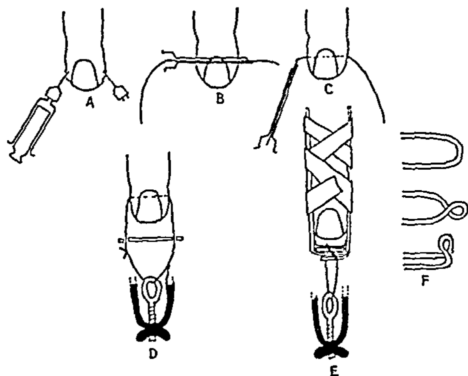


Fig. 601. Method of producing traction for finger and metacarpal fractures. (A) Each side of the fingertip is anesthetized with procaine, a 20- or a 22-gauge needle is passed through the phalanx, and (B) a heavy stainless-steel wire is inserted through the needle. (C) The needle is withdrawn. (D) A wood or a metal spreader is incorporated, and the wire is tied through the opening of the traction screw. (E) Adhesive traction may be used. (F) Bending the loop. (Kaplan, Louis. S. Clin. North America 20:1695)



Fig. 602. (A) Fracture of the neck of the fourth metacarpal. (B) After reduction (retouched), the cast is shown in Figure 605A. (C) Fracture of the shaft of the second metacarpal. (D) Fracture of the base of the fifth metacarpal (E) Fracture of the shaft of the fifth metacarpal with marked angulation. (Kaplan, Louis: S. Clin. North America 20:1695)



Fig. 603. Deformity after fracture of the fifth metacarpal of the left hand. The prominence of the knuckle has disappeared.

may be involved. The common site of fracture is at the neck, but the shaft or the base may be involved (Fig. 602). The distal fragment is flexed by the action of the interosseous muscles and the lumbricals on the base of the proximal phalanx, the proximal phalanx coming to rest in slight extension.

Diagnosis

Swelling often masks the characteristic deformity; the flat dorsal surface becomes convex and perhaps irregular, the dorsal prominence of the knuckle is lost (Fig. 603), and the head of the metacarpal becomes more prominent in the palm. When the fracture is incomplete, localized tenderness and pain on percussion in the long axis aid in the diagnosis. A roentgen examination is made to verify the diagnosis, to determine the displacement and to search for additional fractures.

Displacements

The distal fragment is flexed, and there is angulation open toward the palm. Slight shortening also occurs. The heads of the second and the fifth metacarpals may deviate medially or laterally, or they may rotate.

Treatment

The first dressing is a well-padded tapered wood splint extending from



Fig. 604. (*Left*) Reduction of angulated fractures of metacarpals and (*right*) cast with continuous traction for fracture of third metacarpal. The same arrangement is used for phalangeal fractures when necessary. (Kaplan, Louis: S. Clin. North America 20:1695)

the lower third of the forearm to the middle phalanx. The splint is 2 in. wide above and 1 in. wide below. It is strapped on firmly with adhesive and covered with a snug flannel bandage.

When the fragments are in good position, the wood splint may be used for the required 4 weeks of immobilization. The unpadded cast is better (Fig. 605), because it fixes the fragments securely, permits active use of the entire hand, and requires a minimum of after-care.

When the fragments are displaced, the swelling subsides in 3 or 4 days with the pressure dressing, aided by elevation and an ice bag. In most cases, reduction is accomplished without anesthesia. Five cc. of 2 per cent procaine solution may be injected into the fracture site if the patient cannot tolerate the pain. Placing the thumb in the palm just behind the metacarpal head and pressing it distally and toward the dorsum, the fingers make counterpressure on the dorsum. Meanwhile, the other hand makes traction on the finger. The displacement recurs as soon as pressure and traction are released. Plaster splints are applied on the dorsal and the palmar surfaces of the affected bone from the lower third of the forearm to the



Fig. 605. (A) Cast used in case shown in Figure 602A and B (B) Cast for fracture of the second metacarpal Note that both casts have been trimmed to allow maximum motion of the uninvolved fingers. (C) Cast for fracture of fifth metacarpal. (Fig. 605A—Kaplan, Louis: Arch. Phys. Therapy 20:397)



Figs 606 and 607. "With one hand the operator introduces *the wire into the* neck of the metacarpal and with the other hand he reduces the fracture by dorsal pressure over the deformity. Traction simultaneously applied to the distal finger is a useful adjunct. Once the fracture feels reduced the wire is driven down the shaft of the bone into the base of the metacarpal At this point the wrist is sharply flexed and the wire forced through the skin over the dorsum of the wrist. The drill or chuck is put on the other end of the wire and used to withdraw the wire through the metacarpophalangeal joint until [the distal end] clears the articular surface," as indicated by free motion of the joint. The wire is cut over the wrist and allowed to slip beneath the skin If this is done with the wrist in a neutral or extended position, sharp flexion will tense the skin over the wire, making extraction easy. Simple fractures of the second, the third and the fourth metacarpals, especially in the vicinity of the neck, require a short lateral wire through the head and into the neck of an adjacent metacarpal to prevent rotation. (Peacock, E. E., Jr. S Clin North America 33:1304)

middle phalanx Circular plaster then is applied to make a cast extending the length of the splints. It passes round the hand and round the plaster splints on the affected finger When a sufficient thickness has been applied, about $\frac{3}{16}$ in., the surgeon places the thumb of one hand in the palm just behind the metacarpal head and presses it distally and toward the dorsum while his fingers make counter-pressure on the dorsum and his other hand makes traction on the slightly flexed finger. By this means, the plaster is made tight just behind the metacarpal head (Figs 604, *left*, and 605), and recurrence of angulation and shortening is prevented. The blood supply here is very good, and pressure sores need not be feared Most patients are very comfortable after a few hours and can begin to use the hand.



Fig. 608 Fractures of proximal phalanges (A) Characteristic angulation. (B) Incomplete reduction over a roller bandage in the palm, a very poor dressing. (C) Fifth finger, displacement and angulation of shaft. (D) Oblique fracture united. Angulation corrected, but shortening allowed the sharp edge of the proximal fragment to come down beyond the joint. Skeletal traction would have given a better result. (E) Anteroposterior view of the same fracture. (Kaplan, Louis: S. Clin North America 20:1695)

The position of the fragments is verified by films, so that another reduction may be performed if necessary. Films are made again at the end of a week. From 5 to 6 weeks elapse before the cast is removed, since these fractures unite slowly. If union is not firm, the constant tension of the interosseous muscles causes a recurrence of angulation. After-treatment simply is vigorous active use.

Peacock[22] has recommended Kirschner wire fixation of many simple or complicated fractures of the metacarpals. The technic for the introduction of these wires is shown in Figures 606 and 607.

The heads of the second and the fifth metacarpals may deviate to one side, or they may rotate, resulting in overlapping of the fingers when the hand is closed if the displacement is not corrected.

Extensive comminution and obliquity require continuous traction (Figs. 601, *right*, and 601) rather than pinning.

FRACTURES OF THE PHALANGES

Following an injury to the fingers, swelling and tenderness are considerable. Deformity and crepitus, when present, make the diagnosis. Often, however, the only definite signs of fracture are well-localized tenderness and pain on percussion on the end of the extended finger. Fractures into the

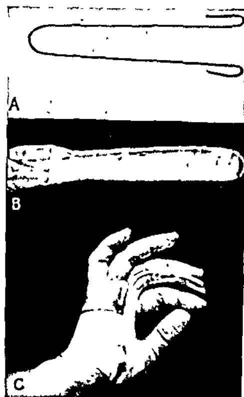


FIG. 609 (A) Ordinary coat-hanger wire was used to make this finger splint (B) The splint should be wrapped in several thicknesses of adhesive. (C) The splint is bent enough for correction at the level of angulation and is secured snugly with adhesive. The adhesive strapping shown is not yet complete. (Kaplan, Louis: S. Clin North America 20:1695)

joints often simulate sprains and cannot be excluded, except by films, when the finger joints are acutely tender. Unusual anteroposterior or sidewise mobility of a joint suggests fracture.

Fractures of the Proximal Phalanges

The types of fracture are shown in Figure 608. When the fracture is complete, the interosseous muscles flex the proximal fragment while the lumbricals and the extensor tendon hyperextend the distal fragment, forming an angle open toward the dorsum (Fig. 595).

Treatment

A well-padded tapered wood splint is applied on the dorsum from above the wrist to the end of the finger. This is secured with adhesive straps, and the dressing is completed with a firm bandage. Films are made.

Treatment of Fractures Without Displacement. If no displacement has occurred, the wood splint may remain for 3 or 4 weeks. Since immobilization in extension leads to stiffness and contracture of the lateral ligaments, it is preferable to immobilize with the finger flexed, in which position the lateral ligaments of the metacarpophalangeal and the interphalangeal joints are not permitted to contract. A bent wire or a metal splint (Fig. 609) is light and comfortable, and it does not interfere with the motion of the other fingers. Another satisfactory dressing is an unpadded metacarpal cast, applied after the swelling subsides, with the finger held in moderate flexion. The cast extends to the fingertip (Fig. 610). It does not become loose, and it does not need to be replaced.

After 3 or 4 weeks, the splint or the cast may be discarded, and the affected phalanx is strapped with adhesive for protection for a week or two.

It is extremely important to exercise every finger fully and to continue the fullest possible use of the hand, the arm and the shoulder during the period of immobilization. Disuse leads to stiffness, pain and atrophy. In the elderly, the disability resulting from disuse may be much greater than that from the original injury.

Treatment of Fractures With Displacement. Displacement requires re-

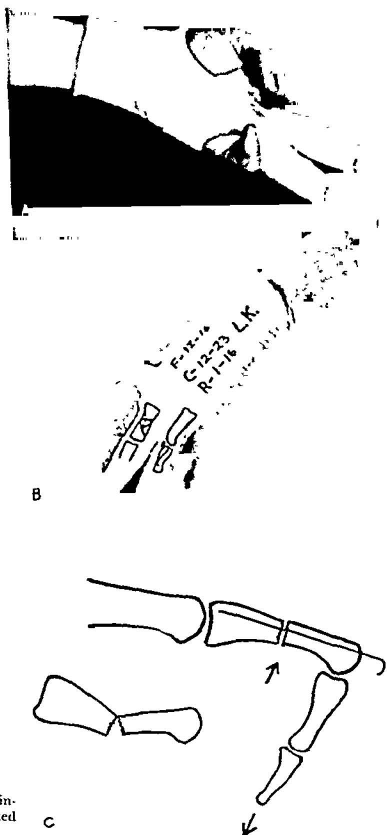


Fig. 610. Unpadded cast for phalangeal fractures with marked comminution. Usually, the flexion of the fingers should be much more than this. (A) Palmar side. (B) Dorsal side. Note the freedom of the uninvolved fingers. (Kaplan, Louis. S. Clin. North America 20:1695)

Fig. 610. (C) Use of intramedullary wire[30] inserted as in Figure 606.

duction. When the fracture is transverse, this may be accomplished by direct pressure. The deformity recurs unless the finger and the hand are strapped firmly to a bent wire splint with the arch of the bend lying at the point of angulation (Fig. 609C). An unpadded cast makes a very good dressing. For this method, it is important to wait 3 or 4 days until the swelling subsides. Elevation and ice bags will expedite this. The fracture is reduced by cross pressure, with the finger flexed moderately, and it is held reduced until the plaster sets.

Full active use may be resumed as soon as the plaster is hard. The position of the fragments is checked by films so that reduction may be repeated if necessary. The cast is removed in 4 or 5 weeks, and the degree of union is determined. If union is not solid, it is best to reapply a cast or a wire splint. Otherwise, the continuous muscle pull may cause a recurrence of the deformity.

Some oblique and comminuted fractures may be held reduced by this method. If good position is not maintained, continuous traction is required. This is done most readily by the use of a stainless-steel wire inserted through the end of the finger after a cast has been applied from lower forearm to knuckles (Figs. 601 and 601, *right*) A bent coat-hanger wire is added on the palmar side of the cast after a loop has been made in the distal end. The stainless wire is led through a spreader and fastened to the screw-traction device. The position of the fragments then may be adjusted by bending the splint and tightening or loosening the screw traction as necessary. Adhesive traction also may be used. Fluoroscopic control or repeated roentgenograms are required.

The position of the fragments is checked every few days during the first 2 weeks. Overtraction must be avoided to prevent delay in union. The cast is removed when the films indicate firm union, 4 or 5 weeks later. The affected phalanx may be protected by wrapping it with 3 layers of adhesive; unnecessary limitation of joint movement must be avoided

Intramedullary fixation with a Kirschner wire has had increasing usefulness.[30] It permits immediate active use of the hand. With suitable anesthesia, the fracture is reduced and held reduced while a Kirschner wire is inserted with a hand chuck, as in Figures 606 and 607, with the joint flexed to 90° to facilitate reduction of the fracture and to allow flexion of the finger afterwards (Fig. 610C). The pin must be inserted almost to the other joint line to ensure stability. The position should be checked by roentgenogram. The end of the wire that remains protruding is bent and covered with a collodion dressing The wire remains for 4 to 6 weeks. Full extension usually returns in a few weeks.

Compound fracture is very common. It is treated by débridement and continuous wire traction, as described above. The hand should be kept elevated during the first week or two.

Fractures of the Middle Phalanges

After fracture of the shafts of the middle phalanges, the bifurcated tendon of the flexor digitorum sublimis flexes the proximal fragment while the distal fragment goes into hyperextension The angle opens toward the dorsum. When the fracture is close to the proximal end, the distal fragment may be flexed by the flexor sublimis.

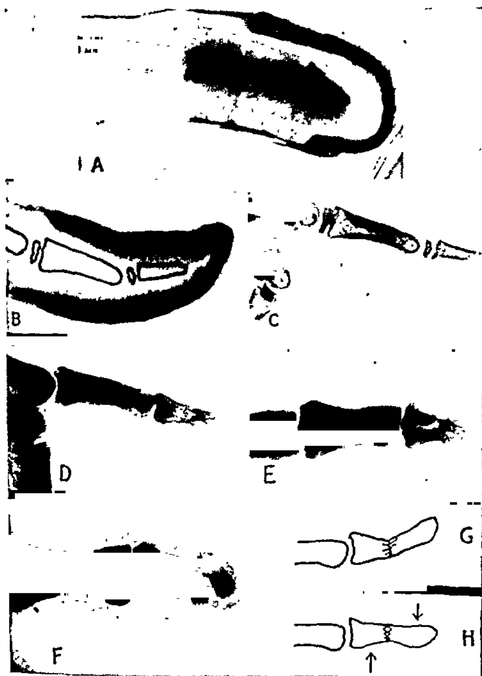


FIG. 611. Fractures of the terminal phalanges (A) Compound epiphyseal separation with avulsion of nail from its bed. Dressed with hairpin splint. The hairpin should have been longer. (B) Reduction, after infiltrating base of finger with procaine, by forced dorsiflexion, which was repeated after applying a plaster thimble up to the base of the finger. (C) Result 3 weeks later (D and E) Fracture into the joint space requiring simple but prolonged immobilization (F) Crushing fracture, to be treated as was (E). (G) Compression fracture with angle open toward dorsum This may be reduced by cross pressure (H) and held in a plaster thimble. (A, B and C—Kaplan, Louis: S. Clin. North America 20:1695)

and the angle then opens toward the palm. The latter displacement is rare.

Treatment

If no displacement has occurred, a bent wire splint is applied on the palmar side from the knuckle joint to the fingertip with the finger in moderate flexion.

When there is an angle open toward the dorsum, it can be reduced by flexion over a bent wire splint alone (Fig. 609C), or it can be incorporated in plaster. It may be treated also in an unpadded cast. The fracture is reduced while the plaster is soft, and it is held in position until it sets Full active use may be resumed as soon as the plaster is hard Intramedullary fixation, as described above, may be used, *especially when maximum immediate* function is desired.

When the angle opens toward the palm, either a plaster dressing may be applied, appropriate pressure being made to secure reduction, or a straight dorsal wood or wire splint from knuckle joint to fingertip may be used *if preferred. The fracture is reduced,* and the finger is strapped firmly to the splint.

Union is not rapid in these fractures; from 4 to 5 weeks of immobilization is required usually.



Fig. 612. Plaster thimble for certain fractures of the terminal phalanx. (See Fig. 613, B, G and H.)

Oblique and comminuted fractures are treated as are similar fractures of the proximal phalanx.

Fractures of the Terminal Phalanges

Fractures of a terminal phalanx usually are caused by crushing injuries or by blows on the extended finger (Fig. 611).

The shaft of the phalanx may show transverse, longitudinal or commi*nuted fractures. Usually, swelling and* pain are considerable. Fractures close to the base may show a marked tilt of the distal portion, which should be reduced.

Treatment

Fractures without displacement may *be immobilized in a hairpin splint* and covered with a small firm bandage, or a plaster finger thimble may be made (Fig. 612). After extensive comminution, the fragments sometimes may be molded into position in plaster after a few days of elevation. About 4 weeks of immobilization usu*ally is required. Compound fractures* are cleaned thoroughly, sutured when necessary, and then treated with a plaster thimble as simple fractures.

Fractures Involving the Joint Surfaces

When the end of the extended fin*ger is struck, a fracture may* occur at the proximal end of any of the phalanges. Sudden violent hyperextension or flexion may be the cause of the fracture in "baseball finger" (Fig. 613G). A small portion tends to split off from the proximal concave articular surface on the palmar or dorsal side. When the fragment is large, dislocation also may be present (Fig. 613). Fixation in extension, as shown

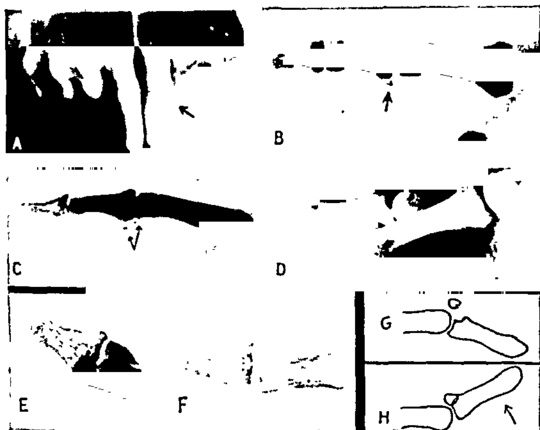


FIG. 613. Types of articular fractures of the finger. (A) Four months after a fracture into the joint space marked thickening, stiffness and pain. (B) A displaced ununited fragment on the side of the thickening. (C) Another fragment on the palmar side. (D and E) Compound fracture dislocation of proximal phalanx of thumb. Débridement, reduction by traction and lateral pressure; immobilization in plaster splints for 6 weeks. (F) Good result. (G) Terminal phalanx compression fracture of the dorsal margin of the articular surface: the extensor tendon retracts the small fragment; the flexor tendon may flex the main fragment, causing a characteristic deformity. Reduction is obtained by applying a plaster thimble similar to that used in Figures 611B and 612 and maintaining extreme dorsiflexion until the plaster hardens (H). If more of the articular surface is broken off, the phalanx may dislocate and may require skeletal traction to maintain position (Figures 613A-D—Kaplan, Louis: S. Clin North America 20:1695)

in Figure 612, may be obtained by forcing the terminal phalanx into full extension.

Blows on the sides of the fingers may cause longitudinal fractures through the joint surface, sometimes accompanied by sidewise subluxation.

Treatment

A dorsal wood splint and a pressure bandage are applied at first. The splint should be long enough to immobilize the affected joint adequately. The displacement is determined by films Many of these fractures may be reduced and held in plaster, angulation and direct pressure on the soft plaster being used to secure apposition of the fragments. When the joint involvement is considerable, and

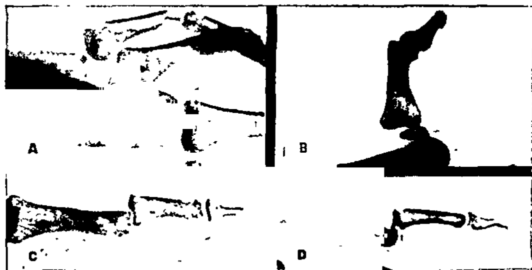


FIG. 614. (A) Compound dislocation of fourth and fifth metacarpophalangeal joints caused by a 10-foot fall, the patient landing on his hand The heads of the fourth and the fifth metacarpals protruded through the skin of the palm. Immediate débridement, reduction, skin sutures only, anterior and posterior plaster splints from elbow to fingertips. Wound healed by first intention. Patient was discharged 3 weeks after injury in excellent condition. (B) Metacarpophalangeal dislocation of the thumb. (C and D) Dorsal and lateral dislocation at the proximal interphalangeal joint with a fracture of the palmar margin of the proximal articular surface of the middle phalanx. (Figs. 614A and B—Kaplan, Louis: S. Clin. North America 20:1695)

when subluxations complicate the fracture, continuous traction may be necessary.

Finger exercises and active use are begun immediately when possible. After from 4 to 5 weeks, the cast is removed, and the joint is supported by a hairpin splint (Fig. 59) or by adhesive strapping. Pain persists for several months, and the joint support is continued during this period. Physiotherapy, such as baking and massage, often increases pain and stiffness, and should not be used as a rule.

Complications

Failure to immobilize adequately and for a sufficiently long time may result in a chronically swollen stiff and painful joint (Fig. 613A).

Compound fracture is very frequent. Failure to reduce fracture dislocations accurately may necessitate open operation.

DISLOCATIONS OF THE FINGER JOINTS

Dislocation of the metacarpophalangeal (Fig. 614A and B) and finger joints of the 4 fingers usually follow hyperextension. The distal bone rests on the dorsum of the proximal. These dislocations often can be reduced by traction without anesthesia. The joint is immobilized in at least partial flexion with a bent wire splint or a cast after films have been made to exclude fractures. Immobilization for 3 or 4 weeks is necessary.

Dislocations of the metacarpopha-

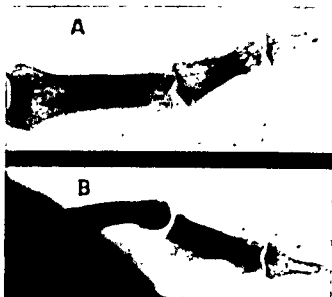


FIG. 615. Irreducible dislocation of the middle phalanx. Six attempts at reduction failed. operative reduction should have been performed after the first or the second attempt.

langeal joint of the thumb (Fig. 614B) also follow hyperextension. The head of the metacarpal protrudes through the capsule of the joint and lies between the short flexor tendons of the thumb. Longitudinal traction tautens these structures about the metacarpal head and makes reduction difficult. This is accomplished best by increasing the hyperextension and making direct pressure on the dorsum of the base of the distal bone while making counterpressure on the metacarpal head. The phalanx then is flexed slowly on the metacarpal. When this maneuver fails, reduction is effected by pressing the hyperextended phalanx firmly toward the ulnar side and then swinging it into flexion as downward pressure is made on the base of the phalanx and upward pressure is made on the metacarpal head. After reduction, an unpadded cast (Fig. 598) is applied from the lower forearm to the distal joint, with the finger held in moderate flexion; this is maintained for from 2 to 3 weeks. Full use of the hand is continued while the cast is worn.

This dislocation often is irreducible and requires operation. An incision is made on the palmar aspect over the metacarpal head, and the tendons are retracted to allow reduction. After closing the skin, a cast is applied.

Dislocation at the carpometacarpal joint of the thumb is less rare than in the other fingers at this level. The deformity simulates that of Bennett's fracture. It is reduced by traction and pressure, and is fixed in a cast for 3 weeks.

IRREDUCIBLE DISLOCATIONS OF THE FINGER JOINTS

In some cases, a finger joint dislocation is reduced and the displacement recurs immediately, either completely or incompletely. When this is the case, the buttonhole type of dislocation has occurred, and reduction of the displacement has caused the capsule to fold in between the bones. Repeated attempts at reduction are useless, and operation is required. It is important to make a roentgen examination of every case after reduction of a dislocation (Fig. 615).

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FIG. 617 (*Left*). Fracture of the patella with slight separation of the fragments.
FIG. 618 (*Right*). Fracture of the patella with comminution and wide separation of the fragments.

TREATMENT

The essentials of treatment are reduction and prolonged immobilization to obtain good healing. Hospitalization usually is necessary. The leg is examined for circulatory, sensory and motor disturbances, and, under general anesthesia, the dislocation is reduced by traction on the leg combined with lateral pressure. If this fails, traction may be made on the flexed knee. After reduction, the leg is splinted, and the patient is kept in bed with the leg elevated. When the swelling has subsided, a gelatin boot (p. 599) and a plaster cast (Fig. 620) are applied, and the patient begins to walk. Exercise of the quadriceps muscle, by raising the leg, is begun at this time and increased daily. The cast remains for 8 weeks in partial dislocations and 12 weeks when the dislocation is complete. When it is removed, the aftercare is as described for ligament injuries (pp 559-560).

FRACTURES OF THE PATELLA

ANATOMY

The patella is an ovoid sesamoid bone lying in the quadriceps extensor tendon. Anteriorly, it is covered by fibers of the tendon; posteriorly, its upper portion is covered by articular cartilage. Strong portions of the quadriceps tendon lie to each side; the portion extending from the patella to the tibial tubercle is called the patellar ligament.

• 29 •

The Lower Extremity

FRACTURES OF THE GREATER TROCHANTER

Etiology

Isolated fractures of the greater trochanter are very rare (Fig. 616). They occur during a fall, by muscular action rather than by direct impact. Sudden violent contraction of the external rotator muscles breaks off their insertion into the greater trochanter.

Diagnosis

After a fall, difficulty and pain on attempting to walk, absence of pain on simple weight-bearing, tenderness over the greater trochanter and limitation of hip motion suggest a roentgenogram. Calcareous tendinitis at the greater trochanter (p. 516) may simulate this condition.

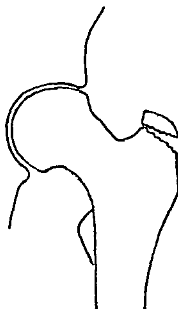


Fig. 616. Fracture of the greater trochanter.

Treatment

Rest and the application of ice bags are advisable until the acute symptoms subside. Then the patient may be allowed to resume his activities within the limit of pain. Procaine infiltration may be tried. For persistent pain with wide separation of the fragments, open operation sometimes is indicated.

A similar separation of the epiphysis *for both the greater and the lesser* trochanters occurs occasionally. The *treatment is the same.*

DISLOCATIONS OF THE KNEE

Etiology

The knee joint may be dislocated by direct violence or by indirect violence, such as hyperextension or excessive rotation. The capsule of the joint and the lateral and the crucial ligaments are ruptured. Cartilage injuries and fractures of the femoral or the tibial articular surfaces are frequent complications. Injury to the popliteal vessels and nerves also may occur.

When the dislocation is incomplete, it may reduce itself spontaneously. When the violence is greater, the tibia may be displaced laterally, medially, forward or backward.





Fig. 617 (*Left*). Fracture of the patella with slight separation of the fragments.
Fig. 618 (*Right*). Fracture of the patella with comminution and wide separation of the fragments.

Treatment

The essentials of treatment are reduction and prolonged immobilization to obtain good healing. Hospitalization usually is necessary. The leg is examined for circulatory, sensory and motor disturbances, and, under general anesthesia, the dislocation is reduced by traction on the leg combined with lateral pressure. If this fails, traction may be made on the flexed knee. After reduction, the leg is splinted, and the patient is kept in bed with the leg elevated. When the swelling has subsided, a gelatin boot (p. 599) and a plaster cast (Fig. 620) are applied, and the patient begins to walk. Exercise of the quadriceps muscle, by raising the leg, is begun at this time and increased daily. The cast remains for 8 weeks in partial dislocations and 12 weeks when the dislocation is complete. When it is removed, the aftercare is as described for ligament injuries (pp. 559-560).

FRACTURES OF THE PATELLA

Anatomy

The patella is an ovoid sesamoid bone lying in the quadriceps extensor tendon. Anteriorly, it is covered by fibers of the tendon; posteriorly, its upper portion is covered by articular cartilage. Strong portions of the quadriceps tendon lie to each side; the portion extending from the patella to the tibial tubercle is called the patellar ligament.



FIG. 619 (*Left*). Plaster splint for knee injuries. A gelatin boot is applied from the toes to the knee. A plaster splint, 6 in wide and long enough to reach from the ankle to the upper thigh, is bandaged on with gauze, which is removed when the plaster hardens Adhesive straps are applied to secure the splint, and an elastic bandage is wrapped about the knee to complete the dressing.

FIG. 620 (*Right*). Gelatin boot and plaster cast for knee injuries

ETIOLOGY

The bone may be fractured by direct violence, such as a fall or a blow on the knee, or indirectly by violent abrupt contraction of the extensor muscles, as in stumbling or in falling on the feet with the knees half flexed. The fracture line is likely to be stellate when due to direct violence and transverse when due to muscular action. The amount of separation of the fragments depends on the extent of the tear of the lateral expansions of the extensor tendon. The fracture line may be a simple fissure 1 or 2 mm. wide (Fig. 617), or there may be a separation of 1 cm. or more, accompanied by extensive lacerations of the lateral portions of the extensor tendon and a wide opening in the knee joint (Fig. 618). The upper fragment is drawn upward by the extensor muscles. There may be an infolding of torn portions of the tendon, or, after comminuted fractures, loose fragments may fall into the joint. There always is hemorrhage into the joint.

DIAGNOSIS

Following a fall or a blow, there is severe pain at the knee, with rapid swelling and an inability to extend the knee and to stand. Acute localized tenderness is present over the fracture line, and there may be palpable separation of the fragments. The knee joint usually is distended by blood.

Acute traumatic prepatellar bursitis may simulate fracture, but the swelling is localized anterior to the lower portion of the patella. A traumatized villus in the floor of the bursa may be acutely tender.

TREATMENT

The preliminary treatment of the knee (p. 553) is given, and roentgenograms are made.

Treatment of Simple Fissure Fractures. When the fracture is a simple, or stellate, fissure in the bone, the splint, the pressure dressing, rest and elevation may be continued until the swelling has subsided. Aspiration is repeated if necessary, and the patient goes about on crutches.

After 5 to 7 days, a gelatin boot (p. 599) is applied from the toes to the tibial tubercle with the foot dorsiflexed. A wide plaster splint is made long enough to reach from just above the ankle to the crease of the buttock,

with several extra thicknesses at the level of the knee (Fig. 619). It is bandaged on the posterior surface with gauze and made secure with adhesive straps 3 in. wide, at least 2 below and 2 above the knee. The knee is kept extended fully until the plaster is hard, and an elastic bandage is applied about the knee to prevent swelling.

In most instances, a cast is preferred. After the gelatin boot has been applied, a strip of felt is placed about the leg just above the malleoli, and a second strip 4 in. wide is placed under the tuberosity of the ischium and about the inner side of the thigh, being secured temporarily by adhesive along the outer side. Plaster splints 6 in. wide are placed on the anterior and the posterior surfaces. Circular plaster bandages 6 in. wide then are wrapped from the lower edge of the lower felt to the middle of the upper felt, 4 to 6 being used as required. The plaster is pressed firmly against the tuberosity of the ischium, and the upper portion of the felt is turned down and secured with a few extra turns of plaster to make a soft edge for the cast (Fig. 620). Instead of plaster, a cast of lighter weight may be made of 3 layers of Castex bandage.

When the splint or the cast is hard, the patient may begin to walk without crutches, and he is urged to walk as much as possible. After 5 or 6 weeks, this support is removed, and a new gelatin boot is applied; an elastic bandage is wrapped about the knee. Gentle flexion exercises, heat and massage are used twice daily at home to overcome stiffness. The boot, the elastic bandage and physiotherapy are continued so long as pain, swelling and stiffness persist, which usually is from 4 to 8 weeks.

The patient may be able to continue at moderate work after the cast is applied, and he may be able to do more strenuous work after 8 to 12 weeks. A practically normal knee may be expected in from 4 to 6 months.

Treatment of Fractures with Separation of the Fragments. When the separation of the fragments is more than 2 mm., operation must be considered. The fragments may be sutured if the fracture is transverse and near the middle. Fracture through the lower third may be treated by excision of all but the largest fragment if that fragment is the upper third.[13] Total patellectomy gives good results in the severely comminuted or neglected fractures.[9]

DISLOCATIONS OF THE PATELLA

Dislocation of the patella usually is due to direct violence. Most often the dislocation is to the outer side; in some instances, the medial edge of the patella is depressed and caught in the intercondylar notch of the femur, making the lateral edge unusually prominent. Rarely is displacement to the outer side complete so that the medial edge of the patella lies against the outer side of the outer condyle of the femur. A dislocation implies some laceration of the quadriceps extensor tendon, which is manifested by hemorrhage or effusion into the knee joint. Dislocation of the patella to the inner side of the knee is rare.

Diagnosis

Pain and swelling at the knee, visible or palpable displacement of the patella and severe pain on attempting to walk are characteristic. Attempts to flex the knee are very painful.



FIG. 621. Fracture of the external tuberosity of the tibia with fracture of the inner spine of the tibia. This is similar to the type shown in Figure 622.

Treatment

The knee joint is aspirated if it is distended and painful. Usually, the dislocation may be reduced without anesthesia. An assistant flexes the thigh on the abdomen with the knee hyperextended. This relaxes the quadriceps extensor muscle completely and allows the surgeon to reduce the displacement by pressing the patella toward its normal position.

A posterior knee splint of wood or plaster and a pressure dressing are applied, and the patient is allowed to walk immediately. Ice bags may be applied for from 24 to 48 hours if there has been much pain and swelling. The splint should be worn for 4 weeks to secure good healing and so avoid recurrence of the dislocation.

If the dislocation becomes of the recurrent type, it may require operation.

FRACTURES OF SINGLE TUBEROSITIES *OF THE TIBIA*

Anatomy and Etiology

The expanded upper end of the tibia forms 2 tuberosities on which the femoral condyles rest. The spongy bone of the tuberosities resists vertical

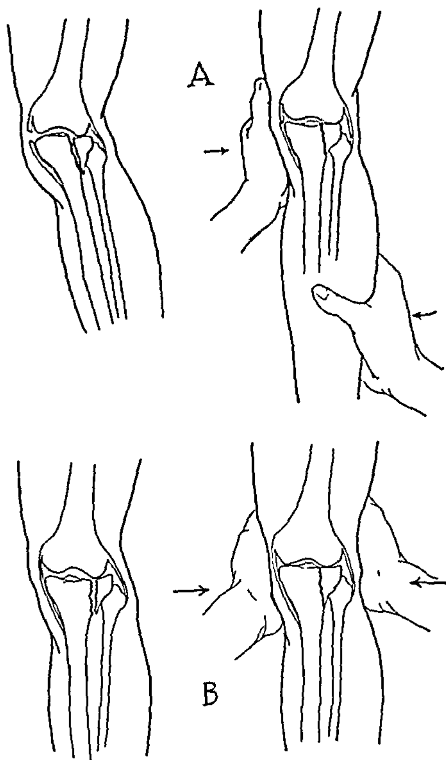


Fig. 622. Correction of displacement of the outer tuberosity of the tibia. (A) Forced adduction of the leg corrects the downward displacement of the tuberosity. (B) Lateral compression corrects the widening.

pressure poorly. When the outer side of the knee receives a blow, the femur becomes a *lever with its fulcrum* at the internal lateral ligament (Fig. 621). The outer tuberosity of the tibia splits off or is pressed downward and impacted, and the upper end of the fibula may break. When the inner side of the knee receives a blow, this lever action of the femur is reversed, and the inner tuberosity of the tibia may be fractured. *Injuries to the lateral* and the crucial ligaments occur often at the time of fracture. The outer side is involved more frequently than the inner.

Displacement

The fractured tuberosity may be split off or displaced downward and impacted (Fig. 622). The displacement may be slight or great, and it can be estimated only by exact anteroposterior and lateral roentgen films. To obtain an exact anteroposterior view, the legs and the feet must be parallel to each other in the long axis of the body, and the films should show a good length of tibia and femur. *An anteroposterior view of the sound knee may be helpful for comparison.*

Diagnosis

The patient may give a history of violent adduction or abduction of the knee while the foot and the body were fixed, followed by swelling, pain and disability. This fracture occurs commonly in pedestrians who are struck by the bumper of an automobile. The whole joint exhibits great tenderness, which is most acute over the side of the tibia involved. If the lateral ligament on the opposite side of the joint has been injured, this area too is acutely tender. If no deformity is visible, the joint is tested for excessive sidewise mobility. Excessive abduction of the leg indicates displacement of the outer tuberosity *if the femur* and the internal lateral ligament are intact. Excessive adduction of the leg similarly indicates displacement of the inner tuberosity. Crepitus sometimes may be felt.

Treatment

The preliminary treatment, consisting *of aspiration of the joint,* pressure dressings, splint, rest, elevation and ice bags, is started (p. 553), and the roentgen study is made. Certain of these fractures are suitable for ambulatory treatment, especially *those with* slight or no downward displacement and those of the splitting type with little displacement (Figs. 621 and 622). It is difficult to reduce downward displacement with impaction, and hospitalization is necessary. Depression of 3 to 4 mm. or more may be an indication for operation. Unreduced lateral displacement also is an indication for operation. Aspiration is repeated as indicated until the swelling subsides.

If there is no marked swelling, the cast may be *applied at once after the initial aspiration, otherwise* it is done in from 5 to 7 days. It is applied from the toes to the tuberosity of the ischium. A strip of felt 10 cm wide is placed under the tuberosity of the ischium and about the inner side of the thigh, being held temporarily by adhesive on the outer side. The length from the ischial tuberosity down the back of the leg over the heel to the toes is measured, and six 6-in. plaster bandages are rolled out to make 3 splints of this length. One is placed posteriorly and secured with circular plaster bandage; the others are applied on the internal and *the external* sides, and the circular plaster is con

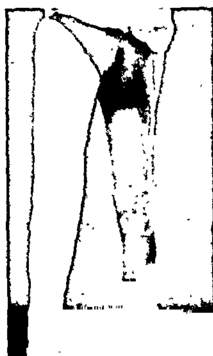


Fig. 623 (*Left*). Cast for fracture of the tuberosities of the tibia. This patient is wearing a small sock and an overshoe over his walking iron. We now use a rubber heel or tire as shown in Figure 612 instead of the iron.



Fig. 621 (*Right*). Fracture of both tuberosities of the tibia. This fracture follows falls on the feet. This is the patient shown in Figure 623. He was treated on an ambulatory basis after several days.

tinued from the webs of the toes to the ischium until the cast is from 1/8 to 3/16 in. thick. The plaster must be molded well at the ischium, the knee and the ankle. While the plaster hardens, the surgeon makes firm lateral compression of the tuberosities of the tibia, and the assistant holds the leg in forceful adduction (for fracture of the outer tuberosity, Fig. 622).

When the cast is hard, a walking iron, or heel, is applied (Fig. 623). The patient begins to walk immediately and to bear weight on the side affected with the aid of crutches. These are discarded in a few days, and the patient is urged to walk as much as possible. The roentgen examination is repeated at the end of 1 week. After 8 to 10 weeks, the cast is removed, a gelatin boot is applied from the toes to the knee, and an elastic bandage is wrapped about the knee. The bandage is removed for baking and massage, and also at night. Active flexion of the knee begins as soon as the cast is taken off, and it reaches 90° in a few weeks if it is performed vigorously several times daily. In some cases, it may be advantageous to remove the cast in 4 to 6 weeks and to use a double upright brace from ankle to upper thigh, with straps to maintain varus (adduction of the leg).[4] Total immobilization should cover a period from 10 to 12 weeks.

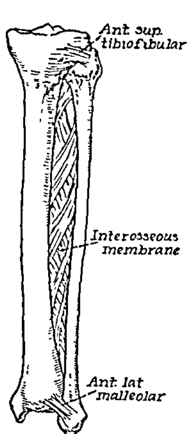




Fig. 625 (*Left*). The bones and the ligaments of the leg. The fibula is bound securely to the tibia by the interosseous membrane and by ligaments at the upper and the lower articulations.

Fig. 626. (*Center*) Incomplete fracture of the tibia. (Right) Spiral fracture. These fractures can be treated well with an unpadded cast and immediate walking.

Prognosis

A good, stable knee joint can be expected if alignment has been secured and maintained. Almost complete flexion and extension will be obtained 2 or 3 months after the cast is removed.

Complications

Injury to the peroneal nerve frequently is an associated lesion, and it should be searched for at the primary examination; a note should be made of this observation. Traumatic peroneal paralysis usually disappears spontaneously in weeks or months, depending on the type and the extent of injury.

Fracture of the upper end of the fibula requires no special treatment if the tuberosity fracture has ben reduced.

FRACTURES OF BOTH TUBEROSITIES OF THE TIBIA

These are the result of severe injuries, and in most instances hospitalization is required for several days at least (Fig. 624).



FIG. 627 (*Left*). Temporary splints for fractures of the shaft of the tibia or of both bones of the leg.
FIG. 628 (*Center*). Molded plaster splints for a fracture of the shaft of the tibia.
FIG. 629 (*Right*). The molded splints have been covered with plaster bandage to make a cast. This is a variation of the method described in the text.

FRACTURES OF THE SHAFT OF THE TIBIA ALONE

Many fractures of the shaft of the tibia, both in adults and in children, need only ambulatory treatment. To this class belong transverse, oblique and slightly comminuted fractures in good position. In fractures that can be reduced easily and are stable after reduction, the patient can become ambulatory after 2 or 3 days in the hospital. Extensive crushing or laceration of soft parts, signs of impaired circulation, or signs of nerve injury make immediate hospitalization necessary. Compound fracture, actual, threatened or suspected, is a surgical emergency.

ANATOMY AND ETIOLOGY

Fractures of the shaft of the tibia follow direct and indirect violence, as by blows, falls and being run over by a vehicle. The bone has large upper and lower ends, and it is narrowest about the junction of the middle and the lower thirds, at which point it is fractured most often. The fracture line may be oblique, transverse or comminuted. The fibula is attached to the tibia by ligaments at the upper and the lower tibiofibular articulations and by a strong interosseous membrane (Fig. 625). When the tibia alone is fractured, the fibula may act as a splint and prevent very great displacement or shortening. In more severe injuries, there is an associated fracture of the fibula.

DISPLACEMENT

Displacement varies with the causative force. In oblique fractures, the line runs often from before upward and backward, the upper fragment becomes prominent, and there may be slight angulation. Transverse fractures may exhibit little displacement (Fig. 626).

DIAGNOSIS

After an injury, there are pain and swelling over the tibia and pain on attempting to bear weight on the foot. There may be visible angulation. Children often have incomplete fractures,

and they are able to walk with a limp. For examination, both legs are placed parallel on a table or a bed, and the visible signs of injury are noted. The crest of the tibia is subcutaneous, and it can be palpated for tenderness and irregularity and compared with the uninjured side. The tenderness of fracture is acute and localized well, except in spiral fractures, when it extends over the length of the fracture site. Percussion of the heel causes pain at the fracture site. It is inadvisable to attempt to elicit crepitus or preternatural mobility. In many instances, the diagnosis must depend on roentgen examination.

Treatment

The treatment aims at reducing displacement and immobilizing the fragments until union is solid. Both the knee and the ankle must be immobilized. The extremity is exercised from the beginning by walking; in this way stiffness, muscle atrophy and circulatory disturbances are avoided.

Immobilization for transportation is provided by applying wood or metal splints from the heel to the upper thigh to prevent motion of the fragments (Fig. 627). The roentgen examination is made immediately.

Reduction is performed by traction and local pressure: in young children, general anesthesia is used, in older people, the fracture hematoma is infiltrated with from 20 to 50 cc. of 1 per cent procaine solution. Fluoroscopic control is helpful. The fracture site is immobilized by 2 molded plaster splints 4 to 6 in. wide and long enough to reach from the sole of the foot to the upper thigh (Fig. 628); these are secured with gauze bandage. A firm flannel or elastic bandage is applied from toes to above the knee. Ice bags are applied for 21 to 48 hours, and the part is kept elevated until swelling subsides, but the patient may go about on crutches when necessary. In the succeeding few days, the bandages are tightened as the swelling subsides.

When the swelling has subsided completely, in from 4 to 7 days, an unpadded cast may be applied. If the plaster splints fit well, and if the fragments are at all likely to be displaced, only the bandages are removed, and dripping-wet plaster bandages, 4 or 6 in. wide, are wrapped on without tension from the toes to the upper thigh to make a cast about 3/16 to 1/4 in. thick. Otherwise, the leg is supported carefully by 2 assistants while the plaster splints are removed. Mastisol glue (p. 637) is painted on the leg just below the knee, and a strip of felt 1/4 in. thick and 2 in. wide is applied just below the crease of the knee round the head of the tibia and the fibula. Two plaster splints, each 6 in. wide and long enough to reach from the upper third of the thigh down the back of the leg over the heel to slightly beyond the toes, are made. The first splint is applied posteriorly and secured with plaster bandage; the second is divided lengthwise. One piece is applied on the outer side of the leg and the other on the inner side. These are secured firmly with circular plaster, which is continued to make a cast 3/16 to 1/4 in. thick, from the webs of the toes to the upper third of the thigh. Roentgenograms are made, if the position is satisfactory, a walking heel is incorporated in the cast (Fig. 642). If there is residual angulation, the cast is cut at the level of the fracture, and a wedge is removed so that the cast may be bent and the angulation corrected (Fig

630). The cut portion is reinforced with fresh plaster. The patient is permitted to go about on crutches, and, after 24 hours, he is urged to bear weight. The crutches are discarded in a few days, and the patient is asked to walk as much as possible.

From 6 to 8 weeks' immobilization for children and from 8 to 10 weeks' immobilization for adults usually is adequate. Roentgen studies are repeated after 1 week, then from time to time as indicated. After 8 weeks, the plaster cast may be trimmed down to the knee so that 1/4 in. of the felt is visible.

After the cast is removed, the part is examined for callus formation, a gelatin boot is applied from the toes to the knee (p. 599), and films are made. If the callus is adequate, the patient is permitted to walk freely. When there is a delay in union, a new cast is applied from the toes to the knee (Fig. 611) for an additional 4 weeks

The gelatin boot is replaced after 2 to 4 weeks, and a wedge 1/8 to 3/16 in. high is inserted in the medial side of the heel to support the arch of the foot The boot is maintained for from 4 to 6 weeks in very young patients and from 3 to 4 months in the elderly. An elastic bandage may be substituted for the boot. Full mobility of the knee and the ankle returns usually in a few weeks. Badly displaced severely comminuted and otherwise unstable fractures should be treated by elevation and continuous traction with a pin or Kirschner wire through the os calcis (Böhler,[2] Hamilton and Jahna[7]).

March Fracture of the Tibia

March fracture of the tibia has been reported in young soldiers.[11] At the onset, there is sudden pain in the upper end of the tibia, accompanied by lameness, during prolonged marching or running. The roentgen findings change: in the first week, there is a fine horizontal fracture line, accompanied by slight callus formation along the periosteum in the second week; in the third week, there is some bone absorption at the fracture line with bands of bone condensation above and below it; from the fourth to the twelfth weeks, the bone condensation increases, and callus forms. The patients are not hospitalized or immobilized; they are treated by physical therapy, and all forms of exercise are avoided.

FRACTURES OF THE SHAFT OF THE FIBULA ALONE

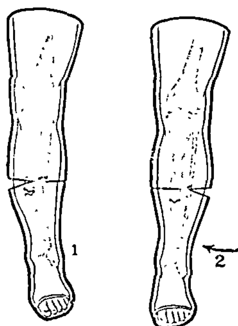
Common fibular fractures occur just above and below the lower tibiofibular articulation (Fig. 635). Isolated fractures in the upper two thirds of the shaft of the fibula follow direct violence (Fig. 631). A heavy layer of fibrous tissue and muscle surrounds the bone and prevents any considerable displacement, unless the violence has been great. Fractures at the neck of the fibula may be complicated by injuries to the peroneal nerve. When displacement is present it usually is toward the tibia.

Diagnosis

A history of direct violence with local pain and tenderness suggests fracture. Roentgen examination usually is necessary to confirm the diagnosis.

Treatment

Reduction seldom is indicated, but it may be attempted for wide displacement. Local anesthesia is given by infiltrating the fracture site with 20 cc.



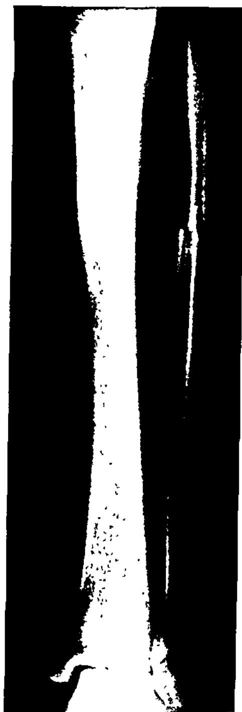




FIG. 630 (*Top, left*). Residual angulation of both bones of the leg may be corrected by removing a wedge of the cast on one side and incising the cast on the opposite side (1). The cast then is bent enough for correction (2) and is repaired with a few circular turns of plaster bandage.

FIG. 631 (*Right*). Fracture of shaft of fibula with slight displacement.

FIG. 632 (*Bottom, left*). Greenstick fracture of both bones of the leg. The lower fragment of the tibia has been displaced slightly to the outer side. The angulation of the fibula is not important.

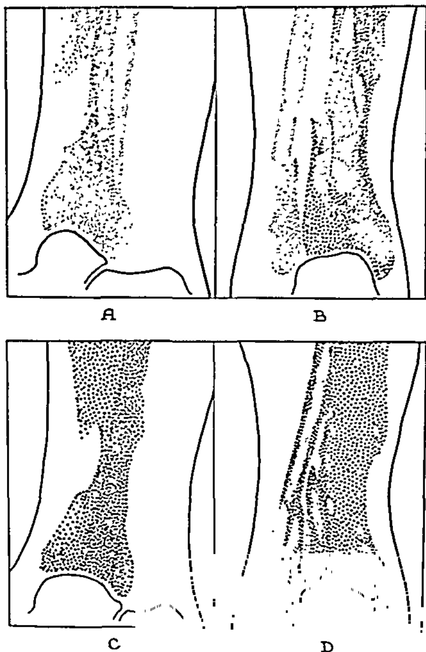


Fig. 633. Drawings made from roentgenograms of a patient with compound fractures of the tibia and the fibula. (A and B) Three months after the injury: there is practically no union. (C and D) Four months later: solid union is present after walking during this time in a brace similar to that shown in Figure 631.

of 1 per cent procaine solution. Traction on and forcible inversion of the foot while the knee is flexed may improve the position of the fragments.

A cast rarely is needed in these cases. A gelatin boot is applied for from 2 to 4 weeks. Persistent discomfort often responds to repeated injections of from 10 to 20 cc. of 1 per cent procaine solution. The prognosis is excellent, except in fractures of the neck of the bone; the possibility of late peroneal nerve involvement must be kept in mind in these cases.

FRACTURES OF THE SHAFTS OF BOTH BONES OF THE LEG

These fractures follow great violence, and often they are compound or are associated with extensive injuries to the soft tissues, hemorrhage

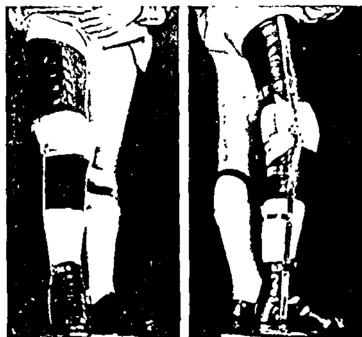


Fig. 631. Walking caliper brace used for delayed union of fractures of the upper end of the tibia. Note the cuff laced firmly above the fracture site.

and swelling. Hospital care is required, except when the position is good or it can be made satisfactory with very little adjustment (Fig. 632).

Treatment

Ambulatory patients are treated as are those with fractures of the shaft of the tibia alone (p. 788). In hospital patients, when satisfactory position has been obtained, swelling has subsided and the fragments have been immobilized securely by a cast or by transfixion pins or wires incorporated in a cast, they may become ambulatory and then are given the treatment described on pages 788 to 789, except that longer immobilization may be necessary.

AMBULATORY TREATMENT OF FRACTURES OF THE LEG AFTER DISCHARGE FROM THE HOSPITAL

Every effort should be made to apply a cast that will permit walking on the leg as soon as possible. Usually, this is done while the patient is in the hospital, but, in some instances, it is applied after discharge. Active use of the leg is the best available form of physiotherapy and the best stimulus to union.

AMBULATORY TREATMENT OF DELAYED UNION OR NONUNION IN FRACTURES OF THE LOWER LEG

In many fractures of the lower leg involving one or both bones, especially when the fractures are compound, there is a long delay in union (Fig 633, A and B). These patients may be treated very satisfactorily by ambulatory methods. Active use stimulates the circulation and appears to stimulate bony union. Edema must be prevented and adequate support given so that walking is possible. The first is accomplished by the long-continued use of a gelatin boot (p. 599) and the

second by incorporation of the shoe in a walking caliper brace (Fig. 634) that reaches to the tuberosity of the ischium. Weight is borne mainly by the tuberosity of the ischium. Leather cuffs are attached to fit the leg above and below the site of fracture.

Operation for nonunion should not be considered until this treatment has been tried for from 6 to 12 months. Many fractures will respond by good union after several months (Fig. 633, C and D).

FRACTURES ABOUT THE ANKLE JOINT

Anatomy

The tibia and the fibula are bound together just above the ankle joint by the tibiofibular ligaments (Fig. 625). These ligaments often are stronger than the fibula and resist widening of the space between the malleoli, in which the astragalus fits snugly. The astragalus tapers slightly from before backward. This tight mortise joint between the tibiofibular unit above and the astragalus below permits free flexion and extension but practically no sidewise or rotary movement of the astragalus. Strong lateral ligaments reinforce the sides of the capsule of the ankle joint. A strong posterior portion of the external lateral ligament (Fig. 446) inserts on the posterior aspect of the astragalus, making the attachments of this bone to the fibula much stronger than to the tibia. When the external malleolus is displaced, the astragalus tends to move with it. The articular surface of the astragalus fits exactly into the articular surface of the lower end of the tibia. When the astragalus becomes displaced, the weight-bearing axis shifts, and, if this is not corrected, serious impairment of ankle function follows. When the space between the malleoli increases as the result of displacement, the astragalus wobbles with each step, and again serious impairment of function is the result.

Etiology

Most fractures about the ankle are caused by indirect violence, the force usually being applied to the foot and transmitted to the astragalus. They are classified according to the violence causing them: (1) fractures by eversion and external rotation; (2) fractures by inversion and internal rotation; (3) fractures by forward or backward thrust against the articular surface of the tibia; and (4) fractures by upward thrust against the articular surface of the tibia.

Fractures by Eversion-External Rotation

Forcible eversion of the foot, that is, elevation of the outer border, rotates the astragalus about its long axis so as to wedge the malleoli apart. The strain is applied to the tibiofibular ligament, which becomes a fulcrum at which the lever action works. The outer malleolus is pressed outward. When it breaks, there is tension on the internal lateral ligament (Fig. 635). The ligament may tear, or the inner malleolus may be broken off. External rotation of the foot, that is, forefoot outward, forces the astragalus to rotate about a vertical axis, and also it acts to wedge the malleoli apart.

Eversion and external rotation usually are combined to cause typical fractures. When the force is not great, there is a fracture of the fibula at or above the tibiofibular ligament, with an irregular transverse fracture line or a line oblique from in front upward

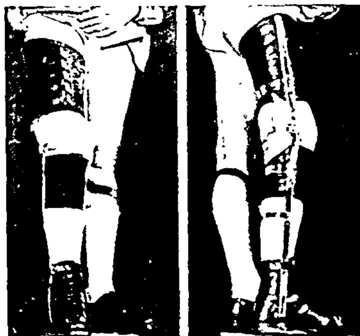


FIG. 634. Walking caliper brace used for delayed union of fractures of the upper end of the tibia. Note the cuff laced firmly above the fracture site.

and swelling Hospital care is required, except when the position is good or it can be made satisfactory with very little adjustment (Fig. 632)

TREATMENT

Ambulatory patients are treated as are those with fractures of the shaft of the tibia alone (p. 788). In hospital patients, when satisfactory position has been obtained, swelling has subsided and the fragments have been immobilized securely by a cast or by transfixion pins or wires incorporated in a cast, they may become ambulatory and then are given the treatment described on pages 788 to 789, except that longer immobilization may be necessary.

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Every effort should be made to apply a cast that will permit walking on the leg as soon as possible. Usually, this is done while the patient is in the hospital, but, in some instances, it is applied after discharge. Active use of the leg is the best available form of physiotherapy and the best stimulus to union.

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Operation for nonunion should not be considered until this treatment has been tried for from 6 to 12 months. Many fractures will respond by good union after several months (Fig. 633, C and D).

FRACTURES ABOUT THE ANKLE JOINT

Anatomy

The tibia and the fibula are bound together just above the ankle joint by the tibiofibular ligaments (Fig. 625). These ligaments often are stronger than the fibula and resist widening of the space between the malleoli, in which the astragalus fits snugly. The astragalus tapers slightly from before backward. This tight mortise joint between the tibiofibular unit above and the astragalus below permits free flexion and extension but practically no sidewise or rotary movement of the astragalus. Strong lateral ligaments reinforce the sides of the capsule of the ankle joint. A strong posterior portion of the external lateral ligament (Fig. 416) inserts on the posterior aspect of the astragalus, making the attachments of this bone to the fibula much stronger than to the tibia. When the external malleolus is displaced, the astragalus tends to move with it. The articular surface of the astragalus fits exactly into the articular surface of the lower end of the tibia. When the astragalus becomes displaced, the weight-bearing axis shifts, and, if this is not corrected, serious impairment of ankle function follows. When the space between the malleoli increases as the result of displacement, the astragalus wobbles with each step, and again serious impairment of function is the result.

Etiology

Most fractures about the ankle are caused by indirect violence, the force usually being applied to the foot and transmitted to the astragalus. They are classified according to the violence causing them: (1) fractures by eversion and external rotation; (2) fractures by inversion and internal rotation; (3) fractures by forward or backward thrust against the articular surface of the tibia, and (4) fractures by upward thrust against the articular surface of the tibia.

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Eversion and external rotation usually are combined to cause typical fractures. When the force is not great, there is a fracture of the fibula at or above the tibiofibular ligament, with an irregular transverse fracture line or a line oblique from in front upward

and backward. When the force is greater, there is a fracture of the fibula complicated by disruption of the mortise because of (1) fracture of the inner malleolus below the level of the ankle joint, (2) rupture of the internal lateral ligament, or (3) rupture of the tibiofibular ligaments causing disruption of the tibiofibular unit.

Fractures by Inversion-Internal Rotation

Forcible inversion of the foot, that is, elevation of the inner border, acts to press the malleoli apart (Fig. 635). The strain falls on the tibiofibular ligament and the external lateral ligament. Internal rotation may occur at the same time and add to the wedging action. When the force is not great, the inner malleolus alone may be fractured, the fracture line running almost vertically upward. When the force is greater, the fracture of the inner malleolus is complicated by (1) fracture of the fibula below the tibiofibular ligament, (2) rupture of the external lateral ligament, or (3) rupture of the tibiofibular ligaments

Fractures by Forward or Backward Thrust Against the Articular Surface of the Tibia (Fig. 635)

When the foot is plantar-flexed and is thrust backward, the posterior margin of the articular surface of the tibia is broken off, and the foot may be dislocated backward When the foot is dorsiflexed and is thrust forward, the anterior margin of the articular surface of the tibia is broken off, and the foot may be dislocated forward. Fractures of an articular margin alone occur less frequently than in combination with fractures of the malleoli.

Fractures by Upward Thrust Against the Articular Surface of the Tibia

These fractures are very rare and follow falls on the feet. The inferior tibiofibular ligaments may be ruptured and the astragalus driven up between the 2 bones. The articular surface of the tibia may be crushed or split, with the astragalus displaced upward between the fragments that lie in front of it and behind it. Lauge-Hansen has described fractures of this type in detail.[8]

Diagnosis of Fractures About the Ankle

The history of an injury causing violent torsion of the foot, followed by severe pain and swelling of the ankle and an inability to walk, suggests a fracture. The ankle must be examined with definite points in mind. Characteristic deformity indicating displacement of the foot may be visible before swelling becomes great. Lateral, anterior or posterior displacement indicates disruption of the mortise. The condition of the soft tissues, that is, swelling, ecchymosis and bleb formation, should be noted.

Acute points of tenderness indicate points of injury. Over the internal lateral, the external lateral and the tibiofibular ligaments it indicates sprain or rupture of these ligaments (Fig. 636). Acute tenderness over the malleoli, below or above the level of the joint, indicates fractures. The entire fibula should be examined, as it may be fractured high in its shaft. Acute tenderness in the space anterior to the insertion of the Achilles tendon suggests posterior marginal fracture of the tibia or fracture of the posterior lip of the astragalus. Sim-

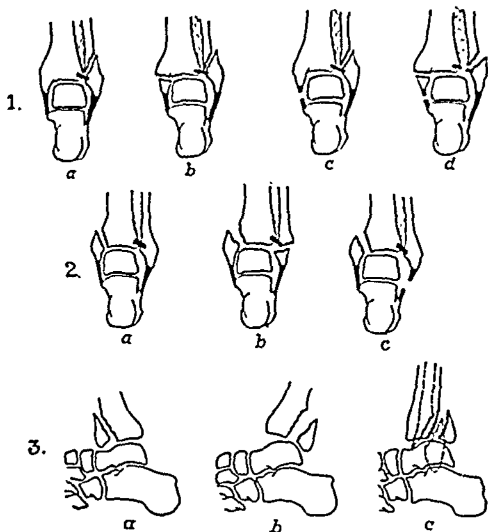
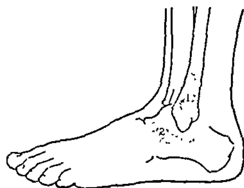


FIG. 635. Types of ankle fractures.

1. Fractures by eversion-external rotation: (a) simple fracture of the fibula above the ankle joint. (b) fracture of the fibula with fracture of the inner malleolus at or below the level of the ankle joint; (c) fracture similar to (b)—the inner malleolus has not been fractured, but the internal lateral ligament has been torn instead; (d) the most severe type of injury, fractures of both malleoli with rupture of the tibiofibular ligament and sometimes rupture of the internal lateral ligament. (b, c and d) These often are complicated by a posterior marginal fracture of the tibia as shown in 3 b and c

2. Fractures by inversion-internal rotation. (a) simple fracture of the inner malleolus running upward from the joint; (b) similar fracture of the inner malleolus with fracture of the outer malleolus below the level of the ankle joint; (c) fracture similar to (b)—the outer malleolus has not been fractured, but the external lateral ligament has been torn instead.

3. (a) Fracture of the anterior margin of the tibial articular surface—this is caused by a forward thrust on the foot, excessive dorsiflexion or a fall on the foot; (b and c) fracture of the posterior margin of the tibial articular surface with posterior dislocation of the foot—this is caused by a backward thrust on the foot or excessive external rotation of the foot, and very often it is associated with I a-d.



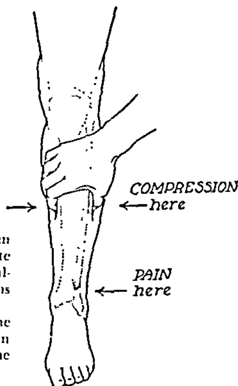


Fig. 636 (*Above*). The tender area in ankle sprains and fractures. (1) The site of tenderness in fractures of the outer malleolus; (2) the site of tenderness in sprains of the external lateral ligament.

Fig. 637 (*Right*). Compression of the bones at the middle of the leg causes pain at the ankle when the lower end of the fibula is fractured.

ilarly, the anterior margin of the tibia is tender when fractured.

Increased sidewise mobility should be sought by grasping the heel, not the foot, and pressing it firmly to the outer side, the inner side, toward eversion and toward inversion. Increased mobility points to disruption of the mortise. This may be checked in roentgenograms by having additional anteroposterior views made in forced eversion and inversion after the tender points have been injected with from 5 to 10 cc. of 1 per cent procaine solution in each side.

The bowlike relation of the fibula to the tibia may be used in demonstrating pain produced by movement at the fracture site. The test is performed by compressing the bones in the middle of the leg This causes no particular discomfort in the ankle in cases of sprain, but, when the fibula is fractured, there is definite pain at the fracture site (Fig. 637).

The roentgen examination is extremely important. Exact anteroposterior and lateral views from the lower third of the leg to the os calcis are the minimum requirement. These may be supplemented by views made in forced eversion and inversion The films should be examined for fractures of the malleoli and articular margins of the tibia, for separation of the tibia from the fibula and for sidewise and anteroposterior displacement of the astragalus. Normally, the articular surface of the astragalus lies exactly beneath the articular surface of the tibia, and it is fitted to a nicety between the malleoli. Widening of the space between a malleolus and the astragalus indicates disruption of the mortise. When there is any doubt, the uninjured side may be examined for comparison.

Treatment

Preliminary Treatment of Fractures About the Ankle

When the examination has been completed, the ankle must be immobilized for transportation (Fig. 658). The foot, the ankle and the lower third of the leg should be wrapped firmly in a 3-in. flannel or elastic bandage to control swelling. Lacking these, a firm gauze or muslin bandage over a layer of absorbent cotton or wool will do. Two board splints, long enough to reach from the heel to the knee, are padded heavily and secured to the inner and the outer sides of the leg with wide adhesive straps. The foot is secured to the splints with a figure-of-eight strap. While waiting for further treatment, the leg is elevated, and ice bags are applied.

For further treatment, the fractures about the ankle are classified according to the severity of the injury as follows:

1. Fractures without displacement of the malleoli and without displacement of the astragalus. These include fractures of the outer malleolus, the fibula above the tibiofibular ligament, the *inner malleolus, both malleoli,* and the anterior or the posterior margins of the tibia.

2. Fractures with displacement of the malleoli and the astragalus. These include *fractures by eversion-external* rotation in which the astragalus is displaced outward, fractures by inversion with the astragalus displaced inward, marginal fractures of the tibia with forward *or backward displacement* of the astragalus and fractures of the tibial articular surface or tibiofibular separation with upward displacement of the astragalus.



Fig. 658. Application of splints for preliminary treatment of ankle fracture. The pressure dressing has been omitted for clarity.

Treatment of Fractures of the Outer or the Inner Malleolus Alone (Fig. 639)

When in good position and without torn *ligaments, these require only* support and a pressure dressing to maintain a useful extremity and to enable the patient to walk without crutches during treatment. When the fracture *is slight, such as a fissure in the bone,* 10 cc. of 1 per cent procaine solution is injected at the site of the most acute tenderness. A firm adhesive strapping is applied (Fig. 447). An elastic adhe*sive bandage or a gelatin boot* (p. 599) may be all that is required to make the patient comfortable. Additional procaine injections may be necessary at intervals of 1 or 2 days. After



FIG. 639. (*Left*) Comminuted fracture of outer malleolus caused by eversion-external rotation. (*Right*) Fracture of inner malleolus in good position.

a few days, the patient should be able to walk with practically no pain. The dressing is reapplied when it becomes loose, and, after 3 or 4 weeks, it may be replaced by an elastic ankle support (Fig. 640).

If the fracture is comminuted, or if displacement seems likely with active function, the strapping and the pressure dressing are replaced with an unpadded cast as soon as the swelling subsides.

Application of the Unpadded Cast (Fig. 641). The patient is seated on a table with the legs hanging over the edge, the uninjured foot being supported on a stool and the injured foot resting with the outer border of the forefoot on the surgeon's knee and at a right angle to the leg. The length is measured with a strip of bandage from the crease behind the knee, down under the heel to 2 in. beyond the toes. The length from the inner tuberosity of the tibia down the leg, under the heel and up to the outer tuberosity is measured with another strip of bandage. An assistant then makes 2 dripping-wet plaster splints of these lengths, using one 6-in. wide plaster bandage for each splint. Plaster with plastic resin, such as Melmac, can be much thinner. The surgeon paints the leg about the tibial tuberosities just below the knee with B-D Adherent or Mastisol and applies a strip of felt 2 in. wide about the tuberosities and the head of the fibula. The first plaster splint then is laid on the back of the leg, from the crease behind the knee, under the heel to the toes, and the end is placed temporarily over the toes. The splint is slit at each side of the heel and folded over to make it smooth. The second splint is folded



FIG. 640. Elastic ankle support.



FIG. 641. Application of unpadded cast for fractures at the ankle. (*Top, left*) The outer border of the foot rests on the surgeon's knee; felt has been applied about the upper end of the tibia. (*Top, center*) The posterior plaster splint (*Top, right*) The lateral plaster splint (*Bottom, left*) Molding at the ankle. (*Bottom, center*) Application of the heel. (*Bottom, right*) A canvas shoe sometimes can be worn

from side to side so that it becomes 3 in. wide, and it is laid on the leg from the inner tuberosity downward, under the heel and up to the outer tuberosity. It is slit in front of the ankle so as to fit smoothly. The plaster over the toes is folded under to come just to the ends of the toes Dripping-wet plaster bandage 6 in. wide then is wrapped on the leg, without tension from the webs of the toes to the knee and with slight tension about the felt strip at the knee to make a snug fit. Five 6-in. bandages are enough for the completed cast; less may be needed in children and more in very obese individuals. While the plaster still is soft, an assistant presses it firmly about the sides of the knee with the flats of his hands, and, as it hardens, the surgeon molds it firmly to the bony contours of the ankle. When the plaster is hard, it should be entirely comfortable. A walking iron, a piece of auto tire, walking heel or shoe may then be attached (Fig. 642), and the patient may begin to walk without crutches after





FIG. 642 Methods of protecting casts for walking. (A) Two rubber heels are nailed together with a strip of leather between them. This is fastened to the heel of the cast with a plaster bandage. (After H. H. Stryker: Surg., Gynec. & Obst. 70:841) (B) Section of auto tire. (C) A large shoe often makes a satisfactory walking device. (D and E) Walking iron.

a few hours. The patient is instructed to walk and to engage in his normal duties as far as possible.

After 4 or 5 weeks, the cast may be removed. A gelatin boot (p. 599) is applied from the toes to the knee. The medial border of the heel is wedged up $\frac{1}{8}$ to $\frac{3}{16}$ in. The boot is retained for from 2 to 6 weeks; the heel wedge, for from 3 to 6 months. If the ankle still feels weak, an elastic ankle support (Fig. 640) is prescribed. These in-



Fig. 643. (*Left*) Molded plaster splints. The original gauze bandage is removed, and the splints are held together with adhesive straps. A firm bandage must be applied from the toes to the knee to complete the dressing. (*Right*) Incorrect application of molded plaster splints. The dorsum of the foot has become edematous. The bandages are loose and do not extend to the base of the toes.

juries rarely require any physiotherapy, but, when they do, the patient is instructed to immerse the foot in hot water for 15 minutes and to massage it for 5 minutes twice daily at home.

An alternative less exacting and less satisfactory method of treatment is the application of internal and external molded plaster splints (Fig. 643), the use of crutches and no weight-bearing for from 4 to 5 weeks. The patient is disabled to a greater extent and has a weaker extremity and less flexible joints when the plaster is removed. The after-care is the same.

Treatment of Fractures of Both Malleoli in Good Position and Fractures of the Anterior or the Posterior Articular Margin (Lipping Fracture) of the Tibia in Good Position (Fig. 644)

These are given the preliminary treatment (p. 797), which is followed by the application of an unpadded plaster cast (p. 798). The cast remains for at least 6 to 8 weeks, and gelatin boots (p. 599) are applied for from 4 to 6 weeks or longer. The heel is wedged up ⅛ to 3/16 in. for from 3 to



Fig. 644. Posterior marginal fracture of the tibia at the ankle in good position.

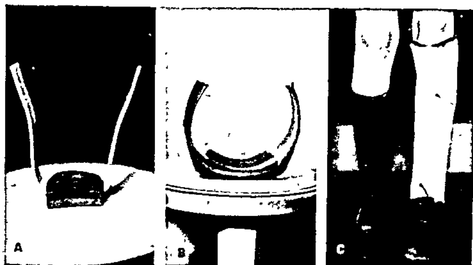




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the foot may help. A strip of felt is fastened below the knee, and 2 plaster splints, from 4 to 6 in. wide and long enough to reach from the knee, down the leg and across the sole of the foot, are made. One is applied on each side of the leg, with the foot at a right angle to the leg but not inverted or everted (Fig. 645), and the 2 splints are bound together firmly with gauze bandage while the surgeon repeats the pressure made for reduction. When the plaster is hard, a firm flannel or elastic bandage is wrapped on from the toes to the knee. Roentgenograms are made, and, if the reduction is not fairly good, it is repeated. Slight residual displacement can be corrected after the swelling subsides, at which time an unpadded cast (p. 798) is applied.

The leg is kept elevated, and ice bags are applied for from 24 to 48 hours after injury. No weight-bearing is permitted. The bandages are tightened as the swelling subsides. When the swelling has gone, the bandages are removed carefully without disturbing the splints. If these fit well, a dripping-wet plaster bandage is wrapped about them to make an unpadded cast. If the splints do not fit well, they are removed, and a new unpadded cast is applied. While the plaster hardens, the surgeon not only molds it about the ankle but also presses the outer malleolus strongly toward the inner side. The foot is held at a right angle to the leg and neither inverted nor everted. Roentgenograms are made immediately after the cast is hard. If satisfactory, a walking heel or iron (Fig. 642) is applied.

The cast is maintained for from 6 to 8 weeks. During this time, the patient is urged to walk without crutches. The cast is replaced by a gelatin boot applied from the toes to the knee (p. 599), and the medial side of the heel is wedged up 1/8 to 3/16 in.

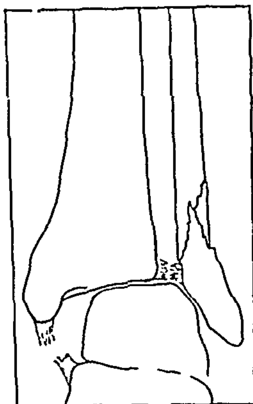


FIG. 646. Drawing made from roentgenogram of a fracture of the external malleolus by eversion-external rotation complicated by rupture of the internal lateral ligament of the ankle joint and rupture of the tibiofibular ligaments. The astragalus has been dislocated outward to an unusual extent. The ruptured ligaments are more serious injuries than the fracture.

In older patients, the boot may have to be reapplied for several months because of persistent swelling, although an elastic ankle support may be enough after from 1 to 2 months.

Treatment of Less Common Eversion-External Rotation Fractures with Displacement

When the external malleolus is displaced outward and the intermalle-



Fig. 645. (*Left*) Fractures following eversion-external rotation. An oblique fracture of the fibula and a fracture of the inner malleolus are seen. The astragalus has moved outward, and the intermalleolar space has widened greatly. (*Center*) The position of the fragments has been improved, but residual displacement still can be seen in the wide space betwen the inner margin of the astragalus and the unbroken portion of the inner malleolus. (*Right*) Full correction by pressure was obtained 1 week after injury, when the swelling had subsided. An unpadded cast was applied.

6 months. An elastic ankle support may be worn after the gelatin boot is removed

Treatment of Fractures with Displacement of the Malleoli and/or the Astragalus

These fractures are serious injuries, since the mortise of the ankle is disrupted and/or the astragalus is moved from the weight-bearing axis. The soft tissues exhibit evidence of severe injury. Without extremely accurate reduction and careful after-treatment there may be great disability. When there is any doubt whatever concerning the ability to manage these patients on an ambulatory basis, they should be given hospital care.

The basic requiremnts for a good result are (1) adequate roentgen study, (2) accurate reduction, (3) adequate measures for reducing the swelling, (4) prolonged uninterrupted immobilization of the fragments until union occurs, and (5) active use of the extremity during the period of immobilization whenever possible.

Treatment of Eversion-External Rotation Fractures with Displacement (Fig. 645)

The most common of these is Pott's fracture. The fibula is broken at or above the tibiofibular ligament, the inner malleolus is fractured below the level of the joint, and the astragalus is shifted outward. Reduction is performed without delay, each fracture site being infiltrated with 10 cc. of 1 per cent procaine solution and from 10 to 15 minutes being allowed to elapse before proceeding; or general anesthesia may be used when preferred. With the knee flexed and the leg hanging over the edge of the table, the surgeon grasps the inner side of the leg above the ankle with one hand and presses strongly inward on the heel and the outer malleolus with the other. Slight internal rotation of

the foot may help. A strip of felt is fastened below the knee, and 2 plaster splints, from 4 to 6 in. wide and long enough to reach from the knee, down the leg and across the sole of the foot, are made. One is applied on each side of the leg, with the foot at a right angle to the leg but not inverted or everted (Fig. 643), and the 2 splints are bound together firmly with gauze bandage while the surgeon repeats the pressure made for reduction. When the plaster is hard, a firm flannel or elastic bandage is wrapped on from the toes to the knee. Roentgenograms are made, and, if the reduction is not fairly good, it is repeated. Slight residual displacement can be corrected after the swelling subsides, at which time an unpadded cast (p. 798) is applied.

The leg is kept elevated, and ice bags are applied for from 24 to 48 hours after injury. No weight-bearing is permitted. The bandages are tightened as the swelling subsides. When the swelling has gone, the bandages are removed carefully without disturbing the splints. If these fit well, a dripping-wet plaster bandage is wrapped about them to make an unpadded cast. If the splints do not fit well, they are removed, and a new unpadded cast is applied. While the plaster hardens, the surgeon not only molds it about the ankle but also presses the outer malleolus strongly toward the inner side. The foot is held at a right angle to the leg and neither inverted nor everted. Roentgenograms are made immediately after the cast is hard. If satisfactory, a walking heel or iron (Fig. 642) is applied.

The cast is maintained for from 6 to 8 weeks. During this time, the patient is urged to walk without crutches. The cast is replaced by a

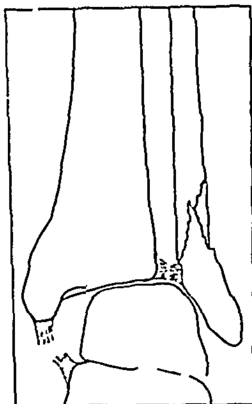


Fig. 646 Drawing made from roentgenogram of a fracture of the external malleolus by eversion-external rotation complicated by rupture of the internal lateral ligament of the ankle joint and rupture of the tibiofibular ligaments. The astragalus has been dislocated outward to an unusual extent. The ruptured ligaments are more serious injuries than the fracture.

gelatin boot applied from the toes to the knee (p 599), and the medial side of the heel is wedged up ⅛ to $\frac{3}{16}$ in.

In older patients, the boot may have to be reapplied for several months because of persistent swelling, although an elastic ankle support may be enough after from 1 to 2 months.

Treatment of Less Common Eversion-External Rotation Fractures with Displacement

When the external malleolus is displaced outward and the intermalle-

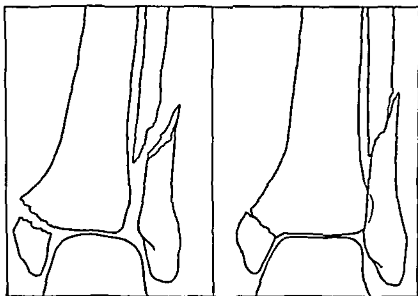


Fig. 647. Drawings made from roentgenograms before and after reduction of eversion-external rotation fracture of both bones with rupture of the tibiofibular ligaments and outward subluxation of the foot.



Fig. 648. Posterior marginal fracture of the tibia and posterior dislocation of the foot complicating a bimalleolar eversion-external rotation fracture.



Fig. 649. Typical deformity after a posterior marginal fracture of the tibia with posterior dislocation of the foot. An ulceration is present over the prominent lower end of the tibia, this was due to excessive pressure from a dressing that had been applied incorrectly

olar space is widened, if the inner malleolus shows no fracture, then rupture of the internal lateral and the tibiofibular ligaments must be suspected (Figs. 646, 647). This may be confirmed by an anteroposterior roentgenogram taken with the foot everted forcibly. Reduction is performed as described on pages 802 to 803.

Fractures of the posterior margin of the tibia with posterior displacement

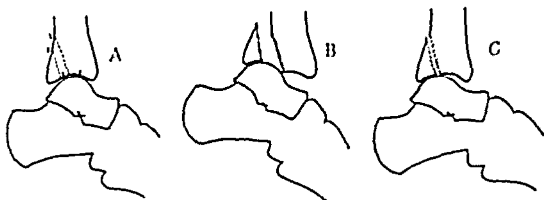


FIG. 650. A. (1) The "classical" type of posterior marginal fracture (after Nelson and Jensen). (2) the "minimal" type of fracture. B Typical displacement. C. In complete reduction. The articular surface of the astragalus is not concentric with the main articular surface. Unless the foot is brought forward to its correct position, the result will be very unsatisfactory.

of the astragalus often complicate the eversion-external rotation fractures (Fig. 618). For these cases, the first maneuver in reduction is to pull the foot forward strongly and dorsiflex it to overcome the posterior displacement. The lateral displacement then is reduced, and lateral plaster splints are applied. While the plaster is hardening, the foot must be pulled forward and dorsiflexed by an assistant while the surgeon presses the outer malleolus inward. The posterior displacement is very likely to recur, so that roentgenograms are made both before and after application of the splints, and again from 7 to 10 days later. When the swelling has subsided, the splints may be converted into a cast (pp. 802-803), which is maintained for from 8 to 10 weeks.

Treatment of Inversion Fractures with Displacement

The inner malleolus is fractured along a line running upward from the articular surface, and the fibula is broken below the level of the ankle joint. The malleoli and the astragalus are displaced toward the inner side. When the outer malleolus shows no fracture and the intermalleolar space is widened, rupture of the external lateral and the tibiofibular ligaments must be suspected. This may be confirmed by an anteroposterior roentgenogram taken with the foot inverted forcibly.

The treatment of these fractures is similar in all respects to that for the eversion-external rotation fractures (p. 802), except that the reduction maneuvers are reversed. The surgeon forces the heel and the inner malleolus outward strongly and repeats this pressure when the plaster is applied. In the after-care, the medial border of the heel should not be wedged up. Persistent displacement of the medial malleolus may be due to soft-part interposition, and requires reduction with internal fixation.

Treatment of Marginal Fractures with Forward or Backward Displacement of the Foot (Figs. 648-650)

Although fractures of the posterior

margin of the articular surface of the tibia with backward displacement of the foot usually are associated with fractures of the malleoli, they may occur without them. Nelson and Jensen[10] have classified these fractures in two groups (Fig. 650): first, the "classical" fracture, in which the posterior fragment involves one third or more of the tibial articular surface; and, second, the "minimal" fracture, in which the posterior fragment involves less than one third of the tibial articular surface. In the "classical" group, the displacement can be reduced, but reduction can be maintained only with difficulty, so that open operation often is required. In the "minimal" group, the displacement can be reduced adequately and maintained easily in plaster Scuderi and Schrey[14] *advise operation when the posterior* fragment involves more than 20 per cent of the articular surface of the tibia.

Reduction is obtained with the knee flexed by making backward pressure on the leg above the ankle and strong forward pull on the foot, accompanied by dorsiflexion. The displacement recurs very easily; therefore, the maneuvers are repeated after the posterior and the lateral plaster splints or the unpadded cast has been applied. Immediate roentgenograms must show complete reduction of the posterior dislocation and complete or almost complete replacement of the posterior fragment. In rare instances, there may be a fixed displacement of the fibula behind the tibia that blocks reduction and may require operation [3] There is on record one successful closed reduction of this variety.[6] After closed reduction failed, the fingers were placed behind the fibular shaft, and a strong pull was applied. After 10 seconds a loud crunch was heard. With additional pull, the fibula snapped back loudly into anatomic position. Failure to maintain reduction of a marginal fracture indicates the need for hospitalization. Roentgenograms are made again from 7 to 10 days later so that recurrent displacement may be corrected. The after-care is similar to that for displaced malleolar fractures (p. 802), except that the cast remains for 8 weeks.

Fracture of the posterior margin of the articular surface of the tibia occurs frequently in parachute jumpers.[15] It may occur alone or associated with malleolar fractures, as described above. When it occurs alone, displacement is apt to be slight, and from 4 to 6 weeks' immobilization *in a walking cast seems to be sufficient*

Fractures of the anterior margin of the articular surface of the tibia with forward displacement of the foot require the foot to be pushed backward and plantarflexed while the leg above the ankle is pulled forward. Displacement recurs readily, and this makes it necessary to use the same precautions and roentgen criteria as in posterior marginal fractures. The after-treatment is quite similar.

Persistent Pain at the Ankle After Fractures

This is caused by (1) relaxed plantar ligaments, (2) a widening of the intermalleolar space, (3) irregularities of the joint surface, and (4) circulatory changes.

Relaxed Plantar Ligaments. Flattening of the arch of the foot may cause no discomfort prior to a fracture at the ankle, but it may be a source of persistent discomfort afterward. After the injury, the further relaxa-



Fig. 651. Old unreduced eversion-external rotation fracture of both malleoli at the left ankle. The ankle is wide, and the foot is displaced outward. This patient had recurrent pain at the medial side of the left knee due to chronic strain.



Fig. 652 (*Left*). Separation of the lower tibial epiphysis by eversion-external rotation. Also present are a fracture through the outer side of the tibial diaphysis and a fracture of the fibula.

Fig. 653 (*Right*). Epiphyseal separation by inversion. Actually, this is a vertical fracture through the epiphysis and the diaphysis. Growth disturbance is likely to follow this injury.

tion of the ligaments of the foot by immobilization and the action of chronic strain on an injured area cause persistent pain. Elevation of the medial border of the heel 1/8 in. or more and the placement of pads under the arches often will relieve the symptoms (p. 625).

Widened Intermalleolar Space. If the space between the malleoli is widened due to failure of reduction, the astragalus can slip sidewise in the joint, and a chronically painful ankle may be the result. If the widening is considerable and the symptoms are troublesome, operation may be indicated (Fig. 651).

Irregularity of the Joint Surfaces. When a posterior marginal fracture of the tibia is not reduced adequately, the astragalus may slip backward in the joint. The joint surface is rough, and a chronic arthritis results.

Circulatory Changes. When edema is not prevented by adequate support, swelling of the ankle may persist for a long time. Often this is associated with excessive fibrosis about the joint and impairment of the circulation. The prolonged wearing of gelatin boots and active exercises are of value. Physiotherapy in the form of heat, massage and contrast baths also may be used. Lumbar sympathetic injection may be of value for persistent pain and swelling.

EPIPHYSEAL SEPARATIONS AT THE ANKLE

It has been pointed out (p. 639) that, usually, epiphyseal separations occur at the diaphyseal side of the



Fig. 654 An unusual type of separation of the lower tibial epiphysis. The epiphysis has rotated outward, and the ankle and the foot have moved with it. (*Left*) anteroposterior view (*Center*) Lateral view. (*Right*) Reduction was accomplished easily by forcing the foot into maximum internal rotation (Kaplan, Louis: S. Clin. North America 17:1637)

epiphyseal cartilage, the cartilage being uninjured. This is the rule in epiphyseal separations at the ankle when they are due to the eversion-external rotation mechanism. The tibial epiphysis is displaced outward, and the fibula is fractured above its epiphyseal line (Fig. 652).

Complications

When the separation is due to inversion, the inner malleolus may be fractured, the fracture line running through the epiphyseal cartilage (Fig. 653). In this type, growth disturbance is more likely to follow; the tibia grows less rapidly than the fibula, and a late deformity occurs. Osteotomy then may be indicated.

When the epiphyseal cartilage has been crushed, there is likely to be growth disturbance. Follow-up physical and roentgen examinations should be made for a year at least—possibly longer—to detect any beginning deformity of the medial side. If the cartilage has been crushed, a varus deformity may follow. Beginning deformity may require operative treatment.[12]

Marked rotation of the foot may accompany epiphyseal separation; it should be corrected during reduction (Fig. 654).

Treatment

Epiphyseal separations are treated as are the equivalent adult fractures.

FRACTURES OF THE OS CALCIS

Etiology

The os calcis is fractured by falls on the feet from a height, rarely by other means. Bilateral fracture occurs frequently, and both heels must be examined when one is injured. Fractures of the lumbar spine are caused by the same violence, and patients with fracture of the os calcis should be examined for fracture of the spine also, and vice versa.

A properly functioning os calcis is essential for painless weight-bearing and walking. Violence may so compress (Fig. 655), widen or shatter the bone that its articulations no longer fit, or they become roughened; its weight-bearing axis also is distorted. Many fracture patterns occur.[15] The constant pull of the gastrocnemius muscle often maintains the displacement. To reduce these displacements and to maintain good position, skeletal traction and pin transfixion may be required.

Diagnosis

Pain in the heel after a fall or a jump from a height suggests fracture of the os calcis. Swelling occurs after a few hours, and ecchymosis appears later. Weight-bearing on the heel causes severe pain. The bone is tender on lateral compression. Comparison with the uninjured side may disclose widening of the heel. Roentgenograms must be made in the axial plane as well as laterally.

Treatment

Only those cases of single or multiple *fissure* fractures without displacement (Fig. 656) and those of isolated fractures of a small portion of the bone are suitable for ambulatory treatment. Narrowing of the tuberosity-joint angle (Fig. 655), displacement or depression of the joint surfaces and widening of the tuberosity require hospitalization and expert care.

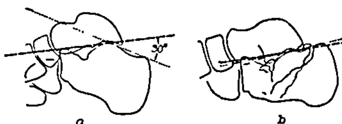


FIG. 655 The tuberosity joint angle (a) The dotted line drawn from the tuberosity to the posterior margin of the articular surface intersects the broken line from the anterior margin of the articular surface to the posterior margin. These lines make an angle of about 30°. When the os calcis is crushed, the angle is decreased or reversed as shown in (b).

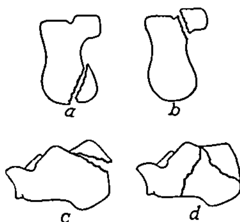




FIG 656 (*Above*) Some varieties of fracture of the os calcis that can be treated by ambulatory methods (after Watson-Jones): (a) simple fracture of the posterior portion of the base; (b) fracture of the sustentaculum tali without displacement; (c) beak fracture of the tuberosity, (d) fissure fractures without displacement.

FIG. 657 (*Right*) Beak fracture of the os calcis

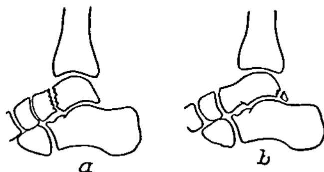


FIG. 658. Two types of fracture of the astragalus: (a) fracture of the neck; (b) fracture of the posterior process. Crushing fractures of the body of the bone also may occur.

The ambulatory cases receive a firm compression dressing immediately to control swelling. A thick flannel or elastic bandage is applied from the toes to the middle of the leg, or the part may be wrapped in a heavy layer of cotton and bandaged tightly with gauze or muslin. The leg is kept elevated; and ice bags are applied for from 24 to 48 hours after injury. After from 5 to 7 days, when the swelling has subsided, an unpadded cast from the toes to the knee and a walking heel are applied (p. 798). No manipulation is required in the fissure fractures without displacement.

The "beak" fracture of the tuberosity (Fig. 657) is reduced by moderate plantar flexion of the foot and direct pressure of both thumbs on top of the fragment at the sides of the Achilles tendon. If the displacement cannot be corrected, operation may be required.

Medial displacement of a fragment of the sustentaculum tali or of a fragment of the tuberosity may be reduced by strong pressure with the thumbs. The cast must be molded well about the heel and the ankle. The foot is kept at a right angle to the leg, except after reduction of a "beak" fracture, in which case slight plantar flexion is preferable. The cast is maintained for from 6 to 8 weeks. The after-care is similar to that for fractures about the ankle. If the plantar surface remains tender, a pad of felt or sponge rubber may be worn in the heel of the shoe.

The prognosis in the simple types of fracture usually is good. Full return of function may be expected.

FRACTURES OF THE ASTRAGALUS

The astragalus may be fractured through its body, neck or posterior process (Fig. 658); these injuries are quite rare. It also may sustain sprain fractures is association with sprains of the ankle.

Fractures of the Posterior Process of the Astragalus

These may follow a fall on the feet or forcible plantar flexion of the foot. The projecting posterior portion of the bone seems to be nipped off, and sometimes it is displaced slightly upward and backward (Fig. 658b). This fracture occurs more often in association with other fractures at the ankle than as an isolated injury.

Diagnosis

There are pain and swelling about the heel and the ankle following the injury. Flexion and extension of the ankle cause pain. When deep pressure is made with the thumbs, acute tenderness is found in the space just anterior to the insertion of the Achilles tendon.

Lateral roentgenograms usually show the fracture well, but it must be remembered that the posterior process of the astragalus may be a separate anomalous bone, the os trigonum, and the two conditions must be differentiated. The os trigonum has a relatively smooth contour as compared with the irregular contour of a fracture line.

Treatment

The displacement usually is negligible. The treatment is similar to that for fracture of the os calcis in good position (pp. 809-811), except that the cast is necessary for only 4 to 5 weeks. The prognosis is excellent, even though bony union is rare.

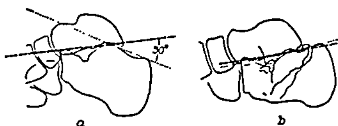


Fig. 655. The tuberosity joint angle (a) The dotted line drawn from the tuberosity to the posterior margin of the articular surface intersects the broken line from the anterior margin of the articular surface to the posterior margin These lines make an angle of about 30°. When the os calcis is crushed, the angle is decreased or reversed as shown in (b).

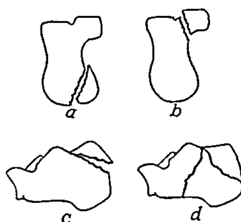




Fig 656 (*Above*) Some varieties of fracture of the os calcis that can be treated by ambulatory methods (after Watson-Jones) (a) simple fracture of the posterior portion of the base, (b) fracture of the sustentaculum tali without displacement, (c) beak fracture of the tuberosity; (d) fissure fractures without displacement

Fig 657 (*Right*). Beak fracture of the os calcis.

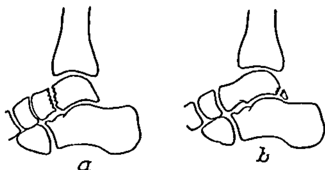


Fig. 658. Two types of fracture of the astragalus: (a) fracture of the neck; (b) fracture of the posterior process. Crushing fractures of the body of the bone also may occur.

moderate dorsiflexion maintained for a time in proportion to the severity of the injury, usually from 3 to 5 weeks.

SUBASTRAGALOID DISLOCATIONS

Etiology

Inversion and eversion of the foot take place at the subastragaloid joint (Fig. 659). When the normal range of motion is exceeded suddenly, there may be a dislocation of the foot at this joint. The astragalus remains between the malleoli, while the os calcis and the scaphoid dislocate with the foot. The dislocation usually is to the medial or the lateral side, rarely forward. Fracture of the astragalus or of the surrounding bones also may be present.

Diagnosis

There is severe pain at the ankle following a violent injury. The dislocation, sidewise or forward, presents a striking deformity quite unlike that of ankle fractures. The malleoli usually are intact and painless. Roentgen study is required to exclude fractures.

Treatment

The dislocation must be reduced promptly. Under general or local anesthesia, the knee is flexed, the foot is plantar-flexed and strong traction is made on the foot, which then is pulled quickly toward its normal position. Two lateral molded plaster splints and a pressure dressing are applied (Fig. 643), the leg is elevated, and the ankle is surrounded with ice bags for from 24 to 48 hours. When the swelling subsides, an unpadded plaster cast and a walking heel are applied (p. 798). The patient begins to walk as soon as the cast is hard and dry. The cast is removed after 6 weeks, and the after-care is similar to that for ankle fractures.

Prognosis

The prognosis is good if there are no complicating fractures of the astragalus.

Complications

Failure to reduce the dislocation, associated fractures or open wounds are indications for hospital care.

MIDTARSAL DISLOCATIONS

In midtarsal dislocation (Figs. 660 and 661), the astragalus and the os calcis are in normal position, and the rest of the foot is displaced. The direction of displacement varies, and accurate diagnosis requires roentgen study. If no fractures have occurred, the dislocation may be reduced by traction and pressure. The additional treatment is identical with that for subastragaloid dislocation.

DISLOCATIONS AT THE TARSOMETATARSAL JOINTS

Many complicated varieties of dislocation occur in this area. They follow great violence, and few of them are suitable for ambulatory care, since exact reduction often requires the use of the screw-traction machine and other maneuvers.

FRACTURES OF THE SCAPHOID, THE CUBOID AND THE CUNEIFORM BONES

When fractures of these bones are present without displacement, the treatment is similar to that for fracture of the os calcis in good position (p. 809). In addition to the other



FIG. 659. Subastragaloid dislocation. (*Left*) Anteroposterior view of the ankle. The astragalus lies in its normal position between the malleoli, and the foot is dislocated to the inner side. (*Right*) View taken with the foot placed flat on the film. The head of the astragalus lies over the tarsal bones on the outer side of the foot, and not in the concave facet of the navicular on the medial side.

FRACTURES OF THE BODY OR THE NECK OF THE ASTRAGALUS

Like fractures of the os calcis, these are the result of falls on the feet, and often they complicate a subastragaloid dislocation. Since most of the surface of the bone is articular, any displacement is serious and requires hospitalization and expert care

Diagnosis

It is very difficult to be certain of a fracture of the body or the neck of the astragalus without roentgenograms. There are pain and swelling at the ankle, and there is severe pain when the patient attempts to bear weight. Acute tenderness may be present over the bone.

Treatment

The treatment and the after-care of simple fractures without displacement are similar to those for fracture of the os calcis. Measures are taken to reduce swelling, and an unpadded cast and a walking heel or iron then are applied (p. 798). The cast is maintained for from 8 to 10 weeks

Sprain fractures of the astragalus at the dorsum of the foot may follow forcible plantar flexion. They may be treated in the same manner as sprains of the ankle, with immobilization in

fractures at the ankle. Many of these patients with metatarsal fractures may be treated well with nothing more than a gelatin boot. The gelatin (p. 599) is applied in a heavy layer from above the ankle to include the toes. Felt pads are cut to conform to the plantar arch, and they are applied after the first layer of gauze bandage. Usually, 2 layers of gelatin and gauze



Fig. 661. Roentgenograms of case shown in Figure 660. Fractures of the bases of the third and the fourth metatarsals. Plantar subluxation of the metatarsals. Fracture of the navicular and the cuboid also were seen in other views. This patient first was seen 6 weeks after injury. He was treated in a gelatin boot, and a very satisfactory functional result was obtained.

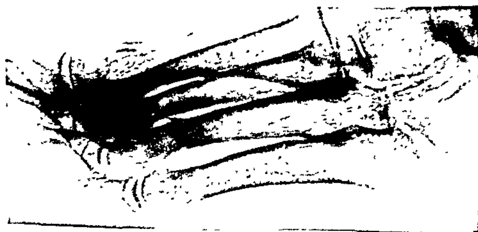


Fig. 662. Fracture of the neck of the fourth metarsal without displacement.



FIG. 660. Dislocation at the midtarsal area with striking increase in the thickness of the left foot. The roentgenograms of this case are shown in Figure 661.

measures, a well-fitted arch support should be worn when the cast is removed. Fractures of these bones with displacement often are due to crushing and require expert care.

Occasionally, a sprain fracture occurs at the dorsum of the tarsal bones due to sudden excessive plantar flexion. The diagnosis may be made by the acute well-localized tenderness over the dorsum of the astragalus, the scaphoid or the cuboid. A snug elastic adhesive bandage makes a good dressing. Active use may be resumed when the acute symptoms subside. Procaine injection relieves the discomfort and helps to reduce the disability.

FRACTURES OF THE METATARSALS

ETIOLOGY (Figs. 661, 662)

These fractures often follow direct violence, such as the impact of a heavy object or being run over by a wheel. They may be caused by indirect violence also. Fractures of the base of the fifth metatarsal often follow sudden inversion of the foot. Most metatarsal fractures exhibit little or no displacement unless the violence has been very great.

DIAGNOSIS

The history of violence followed by pain, swelling, ecchymosis and an inability to walk is suggestive of fracture. There are acute localized tenderness over the fracture line and increased pain when the toe is pressed proximally in the long axis of the metatarsal. Fractures with great displacement swell very rapidly. The deformity is readily palpable. The site of fracture becomes acutely tender. In children of from 11 to 16 years of age, it is important to differentiate in the roentgenogram between a fracture and a normal epiphysis of the tuberosity at the base of the fifth metatarsal.

TREATMENT

When there is a fracture in good position, a felt pad is applied to the plantar surface to conform to the arch, and a firm flannel or elastic bandage or a gelatin boot is applied from the toes to the knee. Ice bags then are applied for from 24 to 48 hours, and the leg is elevated until the swelling subsides. When there are multiple fractures, an unpadded cast and a walking heel or shoe may be applied from the toes to the middle of the leg (Fig. 663) or to the knee (Fig. 641). This remains for from 4 to 8 weeks The longitudinal arch must be molded well, and the foot must be at a right angle to the leg. Walking begins when the cast is hard. An arch support is used in the after-care in addition to the other measures for

longed discomfort in the foot when angulation remains, particularly when the angle is open toward the dorsum of the foot.

FRACTURES OF THE SESAMOID BONES OF THE FOOT

There usually are 2 sesamoid bones in the flexor tendons beneath the head of the first metatarsal. In rare instances, a congenitally divided "bipartite" sesamoid may be found: this should not be mistaken for a fracture After a fall on the feet, the fracture of a sesamoid may be identified by the acute tenderness on the plantar surface just to the inner or the outer margin of the head of the first metatarsal. The treatment is identical with that for fracture of a metatarsal.

MARCH FRACTURES OF THE METATARSALS

Fractures of the second, the third and the fourth metatarsals may occur without a single acute trauma, but a history of unusual exertion or of a long walk may be elicited on pointed questioning. In soldiers, symptoms sometimes begin during a long march "The *etiologic background* appears to be a functional overload on a poorly conditioned foot."[5]

Diagnosis

The first symptom usually is a crampy ache or burning pain in the fore part of the foot. It may be felt only on weight-bearing, or it may be constant. Swelling is present over the dorsum of the foot in mild cases and also on the plantar aspect in the severe ones. There is acute tenderness at the site of the fracture. There may be a history of onset during or after a prolonged or a forced march. Roentgenograms may not show the crack in the bone in the first few days until some decalcification takes place. After 3 weeks, periosteal proliferation may be visible. This may be confused with syphilitic periostitis or bone tumor, but careful inspection of the films will show the fine fissure in the bone.

Treatment

In very mild cases, a gelatin boot and an arch support may be used, with a thick pad beneath the head of the first metatarsal if it is shorter than the second or if the medial side of the foot flattens excessively on standing. For the more severe cases, the application of an unpadded cast from the toes to the knee (Fig. 611) for from 4 to 6 weeks or longer is the method of choice. A gelatin boot is applied afterwards. A pad is used as described above when necessary, or a well-fitted arch support may be worn.

DISLOCATIONS AT THE METATARSOPHALANGEAL JOINTS

These dislocations are very rare. The displacement may be reduced by *traction and pressure. Dorsal dislocation* at the joint of the great toe may require extreme hyperextension or lateral bending to disengage the head of the metatarsal from the flexor tendons. The after-care is similar to that for fractures of the toes (see below).

FRACTURES OF THE TOES

Etiology

Fractures of the toes result from the impact of a falling object or from stubbing the toe. The great toe is involved most often by crushing injuries.



Fig. 663 A plaster cast for multiple metatarsal fractures. When walking, the patient wore a soft shoe, as shown in the upper left corner.

are sufficient. The patient may wear a cut-out shoe, which enables him to walk comfortably after from 7 to 10 days.

Fractures of the base of the fifth metatarsal (Fig. 664) may require only firm strapping with adhesive or an elastic adhesive bandage if the symptoms are not severe. A procaine injection at the fracture site relieves pain and discomfort. Most of these patients walk without disability in from 6 to 8 days.

When there is considerable displacement complicating fracture of a metatarsal, it must be reduced as accurately as possible. Under local or general anesthesia, assistants make traction on the toe and countertraction on the foot and the leg above



Fig. 664. Fracture of the tuberosity of the fifth metatarsal.

the ankle. The toe or the toes may be wrapped in adhesive to obtain a better grip. The surgeon presses on the fragments to restore normal position. In the presence of great swelling, reduction may be deferred for a few days while the part is elevated. Oblique and unstable fractures require continuous skeletal traction as for similar fractures of the metacarpals.[1]

Since the first metatarsal bears a large share of the weight of the body, it is particularly important to correct any angulation of its fragments. Some slight displacement of the other metatarsals is not of such importance.

Prognosis

When there is no displacement, the prognosis is excellent. When there is great displacement, the prognosis depends on accurate reduction and adequate after-care. There may be pro-

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Displacement

This is seldom great. When present, it is seen in fractures of the proximal phalanges in a manner similar to the displacement seen in the phalanges of the fingers (Fig 595).

Diagnosis

There is a history of a characteristic injury followed by pain, swelling and tenderness of the toe involved. The toe may be abnormally mobile, and crepitus may be felt.

Treatment

Unless there is considerable displacement which is likely to lead to deformity, no reduction is required. When the phalanges of the great toe are involved, a gelatin paste dressing (p. 599) may be applied to the toe and the foot. A similar dressing may be used for the second to the fifth toes, or these may be treated by strapping the fractured toe with adhesive. A molded wire splint, applied on the dorsum from the distal third of the foot to the tip of the toe, may be useful. It should be anchored with several layers of adhesive, including one toe on each side of the fractured one when possible. Procaine injection relieves the pain and disability. A shoe may be worn; a larger shoe or a slit in the toe may be necessary to avoid pain from pressure.

Displacements of the distal or the middle phalanges are reduced easily by traction and pressure or molding, and the position is maintained by the dressing. Fractures of the proximal phalanges sometimes prove to be troublesome, but they rarely need dressings other than described above.

Support should be continued until there is no tenderness or pain. In simple fractures, only the adhesive dressing may be needed after a week or two, and the patient may wear his regular shoe if it does not cause severe pain.

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